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A NEW GAMASID (ACARINA: MESOSTIGMATA) INHABITING THE TYMPANIC ORGANS OF PHALAENID MOTHS

Asher E. Treat

The City College of New York

During the summer of 1952, several phalaenid moths collected near the village of Tyringham, Massachusetts, were found to harbor colonies of parasitic mites in their tympanic air sacs and associated cavities. The following summer, 151 infested moths were collected at the same station, representing 23 species of 18 genera and 4 subfamilies—all phalaenids. Specimens of the mite were sent to Dr. G. W. Wharton, at whose suggestion and with whose very generous and extensive help the present paper was written. The damage to the host caused by these mites includes the destruction of the tympanic membrane and chordotonal organ. Other effects will be described later in this report.

The assignment of the species to the Genus *Myrmonyssus* is purely provisional. Although its relationship appears closer to this group of laelaptids than to any other, it differs in significant ways from the characterization of *Myrmonyssus* as given by Berlese (1903a and b), and as summarized recently by Baker and Strandtmann (1948). According to the latter authors, "The following characters appear to be distinctive of this genus: Fixed chela of chelicerae weakly developed, blunt; both chelae without teeth; dorsal shield large, blunt on rear, covering all but the posterior portion of body; anal plate on rear of mite; coxa I–IV each with a pair of setae; tarsal claws lacking; genito-ventral plate pointed on rear, not reaching anal plate. *Type: Myrmonyssus diplogenius* Berlese 1903, collected in ants' nests, Italy."

DESCRIPTION

Myrmonyssus phalaenodectes, new species

Female (Plate I): Palpi about half the length of leg I, the two tines of the forked seta curving medially. Chelicerae moderately stout; movable chela strongly curved, pointed, and with a single, well-developed secondary tooth or claw (Plate I, c). Two blunt, tapered lobes, possibly representing the fixed chela, flanking movable member. Tectum smooth, triangular. Hypostome (Plate I, d) with broad, lanceolate processes (or corniculi?). Salivary styli present. Deutosternum with 12 to 14 rows of 2 to 5 minute teeth, which are difficult to detect without dissection. Tritosternum smooth. Propodosoma slightly constricted between legs I and II. Sternal plates fused with jugulares, weakly sclerotized, with anterolateral angles extended toward the anterior borders of coxae II, and with broadly recurved posterior border between coxae III. Three pairs of jugulo-sternal setae. No endopodal plates or setae. No pores distinguishable. Genito-ventral plate spatulate, variably notched at the anterior end, broadening posteriorly, with bluntly rounded rear margin, and variably marked by a flamboyant pattern of ridge-like thickenings. A single pair of setae arising from the thin cuticle flanking the posterior portion of the genital plate. Genital orifice a distensible, pocket-like slit between coxae IV, its medial margin reinforced and extended anteriorly by the genito-ventral plate. Metapodal plates absent. Dorsal plate broad and bluntly rounded at both ends, with slightly sinuous margins; near its center, two pairs of setae (Plate I, b). Length of peritremes about 60 microns,

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extending to about middle of coxae III, and surrounded by narrow and elongated peritremal plates (Plate III, b). Anal plate terminal, with a median dorsal seta, a pair lateral to the anus, and a row of 2 to 4 or more along the ventral margin. Ventral surface of opisthosoma and other non-sclerotized areas striated (in specimens treated with lactic acid), and bearing irregularly scattered setae posteriorly. Venter of non-engorged females usually with a crescent-shaped cuticular fold or furrow about midway between genital orifice and anal plate. All legs with pretarsi, caruncles, and minute claws; smallest claws on leg I. Legs I and IV about two thirds as long as idiosoma, averaging 385 microns; leg II, 354 microns; leg III, 350 microns. Coxa IV with single seta; coxa II without tooth or spur. Idiosoma of engorged specimens about 570 microns in length and 270 microns between the peritremes; greatest width and depth both about 290 microns in mid-region of opisthosoma. Idiosoma in non-engorged females about 445 microns in length and 200 microns in maximum width, between the peritremes. Young females colorless or translucent brownish grey; engorged specimens pale straw yellow, deepening somewhat with age; legs often with pinkish tinge in mature specimens.

Male (Plate II): Palpus apparently lacking two-tined seta. Chelicerae stout at base, narrowing rather abruptly toward tips (Plate II, d). Fixed chela bluntly rounded and undivided; movable chela (Plate II, c) with two long, slightly recurved blades or tines connected by a delicate membrane. Tectum prolonged anteriorly in a bluntly rounded lobe. Hypostome with a single pair of setae and with broad, smoothly rounded corniculi. Salivary styli present. Tritosternum smooth, shorter than in female, and deeply divided at base. Ventral sclerotization as in Plate II, b. Genital aperture at or near anterior border of sternal plate, its apparent position varying with retraction of gnathosoma. Dorsal plate broad, covering anterior four fifths of body, its outlines not easily discernible in dorsal view, but seen clearly from side (Plate III, a). Four central setae as in female. Peritremes about 24 microns in length, scarcely reaching anterior border of coxae IV. Anal plate terminal, typically with one median and two lateral setae, but in occasional specimens with an additional seta variably placed. All legs with caruncles and claws, latter being much stouter than in female and originating on tarsi. All legs with stout, spine-like setae. Leg I, 230 microns; leg II, 200 microns; leg III, 230 microns; leg IV, 262 microns. Coxa IV with single seta. Idiosoma 374 microns long, 226 microns wide, and 185 microns deep. Living mite deeper yellow than mature female, and with legs often distinctly pinkish.

Egg (Plate IV, a): Smooth, pearly white, with thin, transparent cuticle; 209 by 183 microns. Specimens mounted in Hoyer's medium often showing a differentiated cortical layer, or containing spherical droplets of various sizes.

Late embryo: As shown in Plate IV, b.

Larva (Plate IV, c): Tritosternum slightly spinose as seen with phase contrast microscope. Anus ventral. A slight cuticular fold sometimes visible (as in figured specimen) between legs I and II. Peritremes not found. All legs with claws. In specimen figured, legs IV of the protonymph faintly visible through larval cuticle. Idiosoma 231 by 170 microns. Color, transparent water-white.

Protonymph (Plate IV, d): Chelicerae fully exserted in figured specimen. The tritosternum appears smooth. Peritremes emergent. Anus ventral. All legs with claws. Idiosoma 292 by 185 microns. Color, translucent greyish white with pale brown of internal organs often showing through transparent cuticle.

Deutonymph (Plate IV, e): Ventral setae more numerous than in earlier stages. Anus subterminal. Chelicerae shown fully exserted and abducted in figured specimen, a frequent appearance in this and preceding stages. Idiosoma 340 by 185 microns. Color similar to protonymph. Sclerotization in this and in earlier stages very slight, making plates difficult or impossible to distinguish. Under the phase contrast microscope, some specimens, at least, appearing with dorsal plate transversely divided.

Holotype: U.S.N.M. No. 2191, a non-engorged female taken from male of *Pseudaletia unipuncta* Haworth, in Tyringham, Massachusetts, July 6th, 1953. The specimen was collected (along with the host and the rest of the colony) in 70 percent alcohol, cleared in lactic acid, and mounted in Hoyer's medium. The allotype male, a paratype, and representative early stages also deposited in U. S. National Museum. Additional paratypes and early stages in collections of American Museum of Natural History, of Dr. G. W. Wharton, University of Maryland, and the author. Specimens figured in author's collection.

Distinctive characteristics of the species are the secondary tooth or tine of the movable chela, the widely separated lobes (of the fixed chela?) which flank the movable member, the presence of but three pairs of sternal setae, a single seta rather than a pair on coxa IV, tarsal or pretarsal claws on all legs, the bluntly

rounded posterior margin of the genital plate and its flamboyant pattern of sclerotization. The parasitic association with and residence in the tympanic organs of LEPIDOPTERA would also appear to be distinctive, since other mites of this genus are, at least conjecturally, myrmecophilous. The association with moths is signalized in the trivial name *phalaenodectes,* from the Greek φάλαινα—a moth, plus δήκτης—one who bites, pricks, or annoys.

INCIDENCE

At the time of writing, 159 infested moths have been collected, out of a total of more than a thousand moths examined. The incidence was highest in moths of the genus *Leucania* and the closely related genus *Pseudaletia,* among which are included the army worm moths. Of 17 specimens of *Leucania pseudargyria* Guenée, 16 were infested (94 percent); for the 2 other *Leucania* species collected (*L. commoides* Gn. and *L. phragmatidicola* Gn.) the combined incidence of infestation was 60 percent—39 infested specimens out of 65. In the northern army worm, *Pseudaletia unipuncta* Haworth, 61 of 93 specimens were infested, an incidence of 66 percent. Of the following species, from one to three individuals, never more than 10 percent, were found parasitized: *Feltia herilis* Grote, *Eurois occulta* Linn., *Graphiphora c-nigrum* Linn., *Eueretagrotis perattenta* Grote, *Polia atlantica* Grote, *Lacinipolia m. meditata* Grote, *Lacinipolia renigera* Steph., *Lacinipolia o. olivacea* Morr., *Orthodes crenulata* Butler, *Orthosia hibisci* Gn., *Septis lignicolora* Gn., *Septis amputatrix* Fitch, *Agroperina dubitans* Walker, *Crymodes devastator* Brace, *Zenobia pleonectusa* Grote, *Apamea americana* Speyer, *Chrysaspidia putnami* Grote, *Autographa precationis* Gn., and *Plusia aereoides* Grote.

The moths examined include not only phalaenids but also amatids, arctiids, geometrids, pyralids, and others having tympanic organs. Mites of the species here described were discovered only on phalaenid moths, and (with the exceptions noted below) only in the tympanic areas.

To date virtually all of the collecting has been done at the same station at Tyringham, Massachusetts, but the finding of an infested female of *Graphiphora c-nigrum* among a half dozen assorted specimens taken near Hohokus, New Jersey, on June 9th, 1953, makes it seem likely that the mites are widely distributed. The seasonal incidence at the Tyringham station appears to be highest in mid-July, though several of the favored host species are on the wing and were examined throughout the season. June 11th and September 5th are the earliest and latest dates of capture of infested moths in Tyringham.

LIFE HISTORY

At present, little can be said regarding the method of transfer of the mites from one host to another, and even less about their winter quarters. Before engorgement, adult females are capable of rather rapid locomotion and will readily desert the host. When transferred experimentally to mite-free moths, they often establish typical colonies. One such colony was started by two females on July 2nd, 1953. By July 9th there were more than 100 mites, and females of the second generation were deserting the host. Another experimental colony was established by permitting a previously mite-free moth to feed upon a single milkweed flowerlet which had been visited by an infested moth and upon which a female mite from that moth had

later been observed. Since army worm moths habitually rest during the day among grasses at the ground surface, it is possible that infestation begins at this time. It was evident that many of the infested moths had not been long in the adult state. Multiple invasion of the host is common, many young colonies having two or more females contributing to the egg mass. It does not appear likely that transfer from host to host takes place while the moths are *in copula,* for mites have never been found on any part of the moth posterior to the first abdominal segment, and when deserting female mites leave the colony, they invariably move forward into the neck and head regions of the host. Both members of a pair of *Leucania* sp. taken *in copula* already had large mite colonies when captured. Whatever the mode of transfer, it must be remarkably effective to produce the high incidence of infestation observed in some species.

The colony is almost always unilateral, one tympanic area of the host remaining mite-free and undamaged even when that of the opposite side is packed with mites and eggs to overflowing. In only one instance was a moth found to have a bilateral infestation when captured. One developed a bilateral infestation under laboratory confinement. Two bilateral colonies were established experimentally, while two other attempts at contralateral inoculation were unsuccessful, the transferred mites either being lost or returning to the old colony. Moths with mites on one side only showed little or no loss of responsiveness to experimental sounds. Those with both tympanic organs damaged were wholly unresponsive.

The earliest sign of infestation is often the absence of a tympanic membrane. Adult females placed experimentally on mite-free moths soon begin to creep about in the thoracic vestiture, exploring each suture or other depression with their mouthparts until they reach the tympanic recess, where they remain. Although the actual process of perforating the tympanic membrane has not yet been observed, it is accomplished within a few hours after invasion of the host, and thereafter the mite or mites are often seen entering or leaving the tympanic air sac.

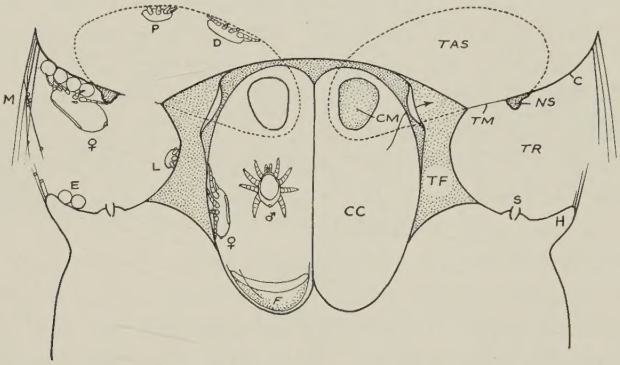
In feeding, the mite applies its palpi and chelicerae to the conjunctiva or to some other area of soft cuticle, which it punctures. The mouthparts are then inserted more deeply. After their withdrawal, a minute droplet of clear liquid, presumably the insect's haemolymph, exudes from the puncture and gradually thickens, forming a black spot. Many such blackened feeding scars may be seen in areas occupied by old colonies, and similar spots on the inner surface of the tympanic air sac indicate that feeding takes place there as well as through the superficial cuticle.

A characteristic feature of the colony, commenced early in its development, is a mat or thatch of the host's setae, held together by the fecal deposits of the mites, and partly or completely screening the tympanic recess and its occupants (Fig. 1, M). In old and populous colonies this mat may become so extensive as to interfere to some extent with the normal folding of the host's hind wing on the affected side. The setae comprising the mat are the greatly elongated ones which, as in many phalaenids, border the exterior margin of the tympanic recess. The development of the mat reflects the curious toilet habits of the nymphal and adult mites. A mite which is about to defecate comes to the outer border of the tympanic recess, turns so as to face inward, and protrudes its posterior end over the margin. As the whitish fecal droplet is extruded, it adheres to one or more of the moth's thoracic setae, where it promptly shrinks (by evaporation?) and turns to a yellow, sticky

or waxy mass. When the moth folds its wings, more setae are likely to adhere to the mass, and in this way, gradually, a dense though easily detachable thatch is formed. Occasionally a dead mite may be found, trapped in the sticky material.

Egg laying commences within a few hours after the invasion of the host. The eggs are placed more or less systematically on the surface of the conjunctiva, finally covering the entire area of this membrane. When several females are ovipositing on the same host, the egg mass may eventually fill the entire tympanic recess and may overflow to adjacent areas at the front and rear. A few eggs have occasionally been found in the tympanic air sac and in the countertympanic cavity (Fig. 1, TAS and CC). The total number of eggs in large colonies may exceed 100.

Oviposition was observed on July 3, 1953. At 10: 30 A.M., two adult females, one fully and one partly engorged, had been transferred experimentally to a previously mite-free male of *Leucania commoides* Gn. After some wandering, both mites settled in the left tympanic recess. The first egg of the new colony was laid



TEXT FIGURE 1. Schematic frontal section through the metathorax and first abdominal segment of a phalaenid moth, showing normal and infested tympanic organs. C, conjunctiva; CC, countertympanic cavity; CM, countertympanic membrane (perforated on the left side); D, deutonymph; E, eggs; F, fecal and exuvial mass; H, hood; L, larva; M, mat or thatch of setae with fecal droplets; NS, nodular sclerite or epaulette; P, protonymph; S, first abdominal spiracle; TAS, tympanic air sac; TF, tympanic frame or "Lamelle"; TM, tympanic membrane (perforated on the left side); TR, tympanic recess. The arrow at the right of CM emerges from the external orifice of the countertympanic cavity.

at some time before 12:35 P.M., the second, at some time between 12:35 and 1:15. From 1:15 until 2:45 P.M. the mites, under strong illumination, were observed continuously with a binocular microscope. They were not affected in any obvious way by the light. They moved freely about the tympanic recess occasionally retreating for a time into the tympanic air sac, and sometimes resting motionless in the deeper part of the recess. At 2:30 P.M., after a prolonged resting period, the fully engorged female came forward and made a puncture in the conjunctiva somewhat lateral to the dorsal part of the nodular sclerite. During this process she inserted her gnathostome to its base, then withdrew it and kneaded the membrane or worked it over in some manner with her mouthparts. After completing the first puncture, she turned away for a few minutes. Then she came back and made a second puncture not far from the first. Once more she turned away, then went back to the first puncture and worked it further with her mouthparts. A small drop of clear liquid was seen on the membrane at this site. At 2:40 P.M. an egg

appeared from under the mite's body. It was quickly passed forward with the aid of the palpi, and was placed upon the site of puncture number one. The mite then turned inward, and was soon moving about the tympanic recess, ignoring the newly laid egg. At 2:55 P.M., she was preparing another site. Between 10:30 A.M. and 8:50 P.M. 6 eggs were laid on the new host. During the next 12 hours 3 more were laid, and before 5:30 P.M. on July 5th a final total of 11 had been deposited. Eggs 3 to 6 were laid at intervals averaging an hour and a half.

One of the 11 eggs in the experimental colony just described failed to hatch, probably because it had been damaged by the female in her repeated casual contacts with it. The remaining 10 eggs hatched in intervals ranging from 43 to 51 hours from the time of oviposition. During this time the laboratory temperature varied between about 18° and 25° C. The actual emergence of the larva was observed in two instances. In both cases the larva emerged rear end first and uppermost, the anterior part of the body being the last to be freed. When enough of the larva had cleared the soft, moist cuticle, the legs were extended one by one from their previously flexed position adherent to the body. As soon as it was free, the larva began to creep slowly inward, over the remaining egg mass, and within 10 minutes of its first appearance it had disappeared in the deeper parts of the tympanic recess. The female occasionally came into contact with the larva during its progress inward, but she did not appear to give it any special attention. After the hatching of the eggs, the conjunctiva presented a pitted and somewhat blackened appearance, in contrast with its normal smooth whiteness.

The newly hatched larvae seem to congregate in the deepest part of the tympanic recess and in the tympanic air sac, where they probably feed by puncturing the very delicate tracheal membrane. Proto- and deutonymphs are also found in these regions, though not exclusively there. The males and young females, with occasional earlier stages, occupy the countertympanic cavity. This (Fig. 1, CC) is a deep and rather stoutly sclerotized thoracic pocket extending into the dorsal portion of the first abdominal segment. Its transparent wall is shaped somewhat like an empty eggshell, and its cavity communicates with the exterior by a lip-like orifice at the anterior end of the tergo-pleural groove, where female mites are often to be seen. The floor of the countertympanic cavity encloses the countertympanic membrane (Fig. 1, CM). The perforation of this membrane by the mites affords an internal passage between the tympanic air sac and the countertympanic cavity. It is likely that the impregnation of the females takes place in the countertympanic cavity. In one moth, no fewer than 55 mites were found in this chamber, of which about 10 were males, the rest almost all young females or deutonymphs. Paired specimens are often found here, the males clasping their mates from above, leaving the legs free. When several such pairs were mounted for microscopic study, it was found that the "females" were actually deutonymphs about to undergo transformation. Since in any event it is unlikely that sperm transfer could be effected in the position described, the embrace may represent a pre-copulatory attitude assumed by the male while awaiting the emergence of the adult female from the nymphal skin.

As the colony develops, the lower and posterior end of the countertympanic cavity becomes filled with a compact plug which is evidently composed of feces and exuviae. In many cases this mass serves as the substrate for the growth of

a mold. In old and partly depopulated colonies, the mycelium of this mold may partly fill the countertympanic cavity, and in some instances the tympanic air sac and even the adjacent muscles of the host are invaded. The older, fruiting hyphae of the mold cause a brown or blackish discoloration in areas occupied by old colonies, while silvery aerial hyphae extend into the open spaces of the countertympanic cavity and tympanic air sac. Cultures of this mold on Sabouraud's agar have been identified by Dr. Kenneth Raper of the University of Wisconsin as a species of *Cladosporium.*

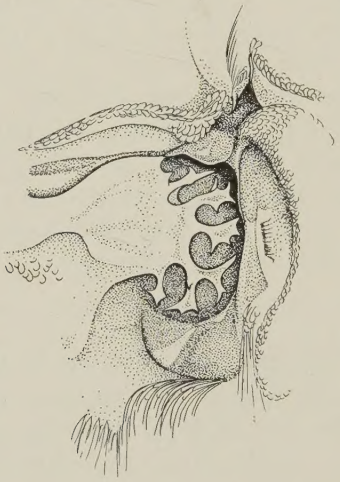
As the females mature—and probably only after impregnation—many of them leave the tympanic region and work their way forward among the thoracic setae to the neck and shoulder region of the host, where they remain active, but deeply hidden at the bases of the patagia or among the long setae of the head and prothorax. Feeding spots have occasionally been found in these areas, and in one case a small fecal hair thatch was present. As a rule, however, the region seems to be primarily a way station *en route* to the abandonment of the original host. At this stage it is common to find one or more mites between the moth's labial palpi, ventral to the base of the tongue, from which position they have often been seen to emerge and to creep along the shaft of the tongue when the latter is extended as in feeding. Wandering females were often found in the jars where heavily infested moths had been confined, and were sometimes seen on the blotting paper from which the moths had been feeding. A few moths have been taken in which, despite unmistakable evidence of previous infestation, no mites remained.

ECOLOGY

Though there is no doubt that these mites are truly parasitic, at least in the generations here described, the damage inflicted upon the host is not as serious as might be imagined. In the rare bilateral infestations, no evidence of auditory function could be obtained. In the usual cases, however, no serious impairment of the auditory sense was detected (see author's paper, in press). Infested moths fed and flew without obvious abnormality. They mated and laid viable eggs. The survival time of affected moths under confinement in the laboratory at room temperature was not significantly different from that of mite-free specimens under the same conditions. Some remained in apparently good condition for more than a week, though fed only honey water and subjected to a daily routine of carbon dioxide anesthesia and more or less prolonged examination. In extreme cases it is possible that wing movement may be somewhat hampered on the affected side, either by the obstructive effect of the fecal seta mat, or by direct damage to the flight muscles by feeding mites or by invasions of the mold described above. Dead or moribund moths had a peculiarly offensive odor, but this differed in degree rather than in kind from that of mite-free moths of the same species. The living moths were not appreciably disturbed by the mites, as far as could be judged from their behavior under confinement and observation. The mites, in turn, appeared to be quite unaffected even by the strongest vibratory movements or by any other activities of their hosts.

In moths of certain species there is a curious, and apparently hitherto undescribed modification of the nodular sclerite ("epaulette" of Eggers, 1919), which would seem to be without adaptive significance except, conceivably, in relation to mites or

to some other possible invader of the tympanic organs. In contrast to the usual form of the epaulette, which is ordinarily a rough or knobby ridge or ledge forming a crescent at the inner border of the conjunctiva, the sclerite in these species bears a row of bizarre, antler-like processes which extend medially so as to form a sort of grill just over, but not touching, the surface of the tympanic membrane (Fig. 2). These antlered epaulettes have been found in 2 out of 4 species of *Lacinipolia* examined (*L. olivacea* Morrison and *L. meditata* Grote), and in 4 out of 8 species, subspecies, or forms of *Acronicta* (*haesitata* Grote, *hamamelis* Guenée, *afflicta* Grote, and *brumosa* Guenée). On the supposition that the antler-like processes might act as mite excluders to protect the tympanic air sac from invasion, a careful watch was kept for infested moths of these species. Two were discovered. In one (*L. meditata*) a few eggs and larvae and one dead, dry adult were found in the outer part of the tympanic recess. The tympanic membrane had been punctured. From



TEXT FIGURE 2. Left tympanic area of *Lacinipolia m. meditata* Grote, ♂, with hood retracted rearward (toward right of figure), showing antler-like processes shielding the tympanic membrane. Drawn from a dried specimen.

the other specimen (*L. olivacea*) 3 adult females, 1 protonymph, and 4 larvae were removed on dissection after the moth had been in the laboratory for 4 days. In this case the tympanic membrane was still intact—the only instance so far discovered of an infested moth with undamaged tympanic membranes. The incidence of infestation was low in all species of *Lacinipolia* collected. Since the evidence from the 2 infested specimens is conflicting, there is not yet an adequate basis for concluding that the antlered epaulettes possess adaptive value in relation to mites. Nevertheless, these and other circumstances suggest a considerable degree of evolutionary interaction between host and parasite, such as would be the expected result of a long period of mutual association.

The author wishes to extend his particular thanks to Dr. G. W. Wharton for examining and identifying the specimens, for assisting extensively in their study, and for reviewing the completed manuscript. Grateful acknowledgement is made to Dr. F. H. Rindge of the American Museum of Natural History for determinations of the host species, to Dr. Kenneth Raper of the University of Wisconsin, and

Dr. Joseph Webb of The City College for identifying the mold associated with some of the mite colonies, and to Dr. Helena Gilder of Cornell University for help in preparing the mold cultures.

SUMMARY

A new parasitic gamasid, *Myrmonyssus phalaenodectes,* occupying the tympanic organs of several species of phalaenid moths, is described. Details are given regarding oviposition, development, and effects upon the host.

REFERENCES CITED

BAKER, E. W. AND STRANDTMANN, R. W. 1948 *Myrmonyssus chapmani,* a new species of hypoaspid mite (Acarina: Laelaptidae). J. Parasit. **34**: 386–388.

BERLESE, A. 1903a Diagnosi di alcune nuove specie di acari italiani, myrmecofili e liberi. Zool. Anz. **27**: 12–28.

————1903b Illustrazione iconografica degli acari myrmecofili. Redia **1**: 299–474.

EGGERS, F. 1919 Das thoracale bitympanale Organ einer Gruppe der Lepidoptera Heterocera. Zool. Jahrb. Anat. **41**: 273–376.

TREAT, A. E. The response to sound in certain Lepidoptera. Ann. Ent. Soc. Am. In press.

PLATE I

FIG. a, *Myrmonyssus phalaenodectes* n. sp., ventral view of engorged female, drawn freehand from paratype taken from *Leucania pseudargyria* Guenée, ♂, Tyringham, Mass., 23 July, 1953. Mounted and cleared in Hoyer's fluid. In collection of the author. Idiosoma 570 microns long. See page 620.

FIG. b, dorsum of non-engorged adult female.

FIG. c, distal end of chelicera of female.

FIG. d, ventral view of gnathosoma of non-engorged adult female, with chelicerae partly exserted. The representation of the deutosternal teeth was added from a dissected specimen.

PLATE II

FIG. a, *Myrmonyssus phalaenodectes,* dorsal view of male. Idiosoma 374 microns long.

FIG. b, ventral view of male.

FIG. c, ventral view of gnathosoma of male.

FIG. d, left lateral view of gnathosoma of male, with palpi omitted, as seen without dissection.

PLATE III

FIG. a, *Myrmonyssus phalaenodectes,* left lateral view of male.

FIG. b, left lateral view of engorged female.

PLATE IV

FIG. a, *Myrmonyssus phalaenodectes* egg, after mounting and clearing in Hoyer's fluid, showing oil (?) droplets. 209 by 183 microns.

FIG. b, right ventro-lateral view of embryo, shortly before hatching.

FIG. c, ventral view of larva. 231 by 170 microns.

FIG. d, ventral view of protonymph. 292 by 185 microns.

FIG. e, ventral view of deutonymph. 340 by 185 microns.

PLATE I

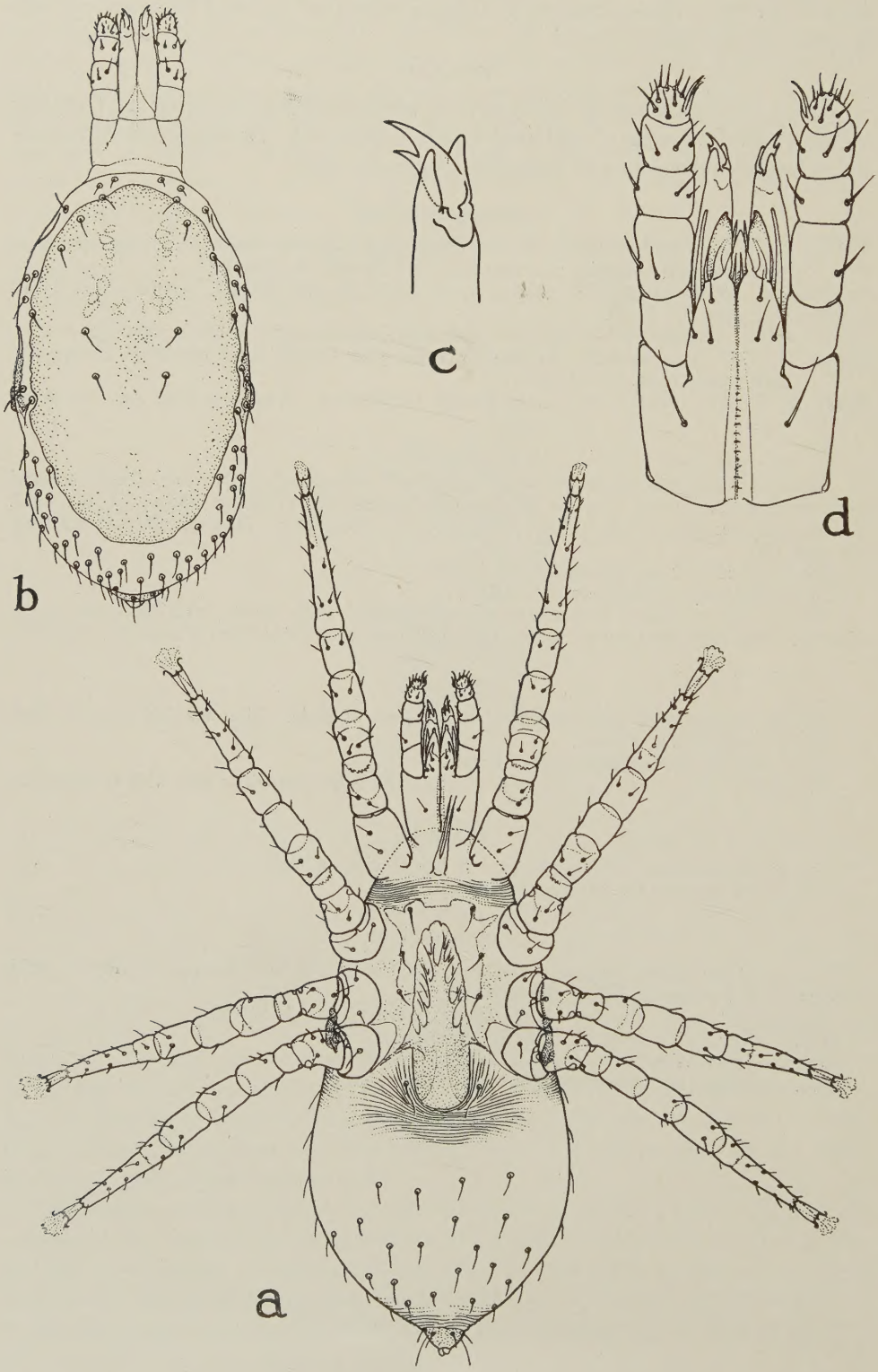


PLATE II

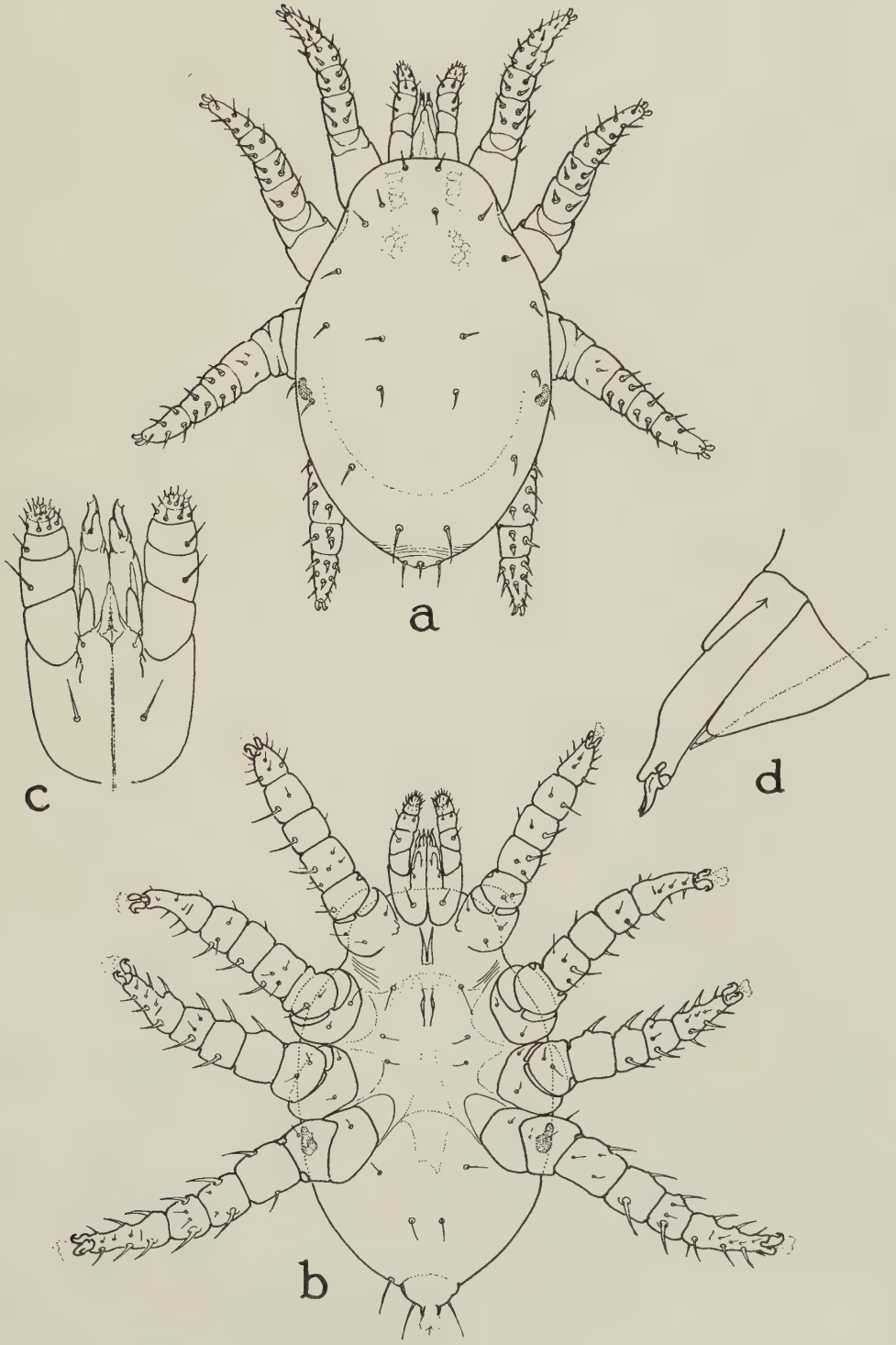
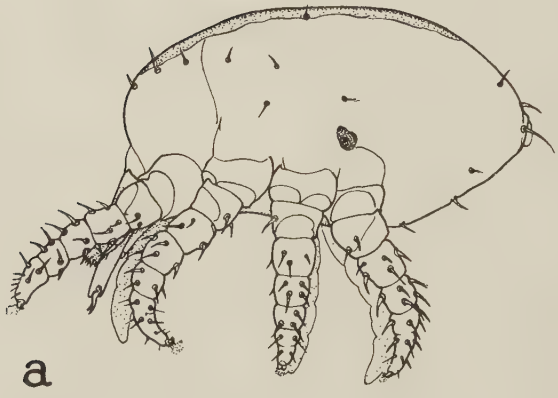


PLATE III



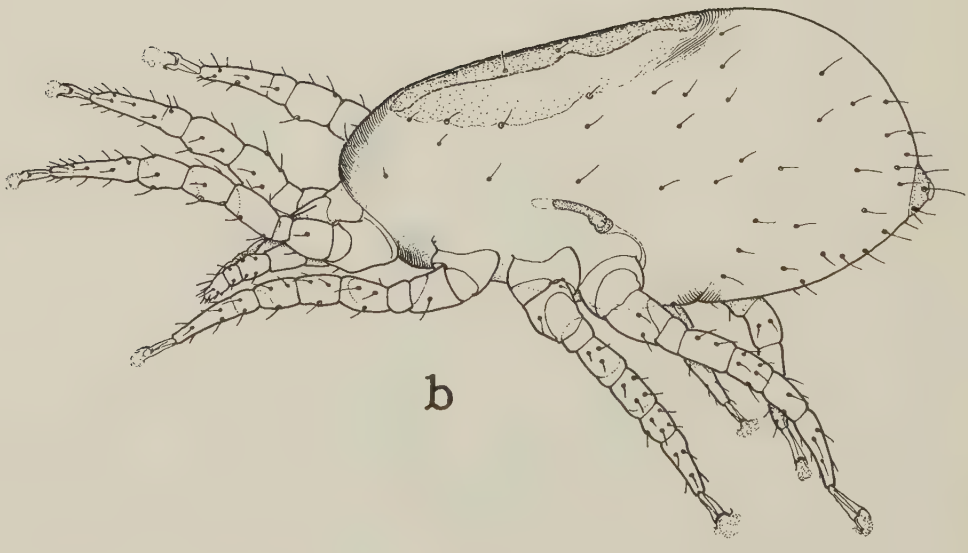
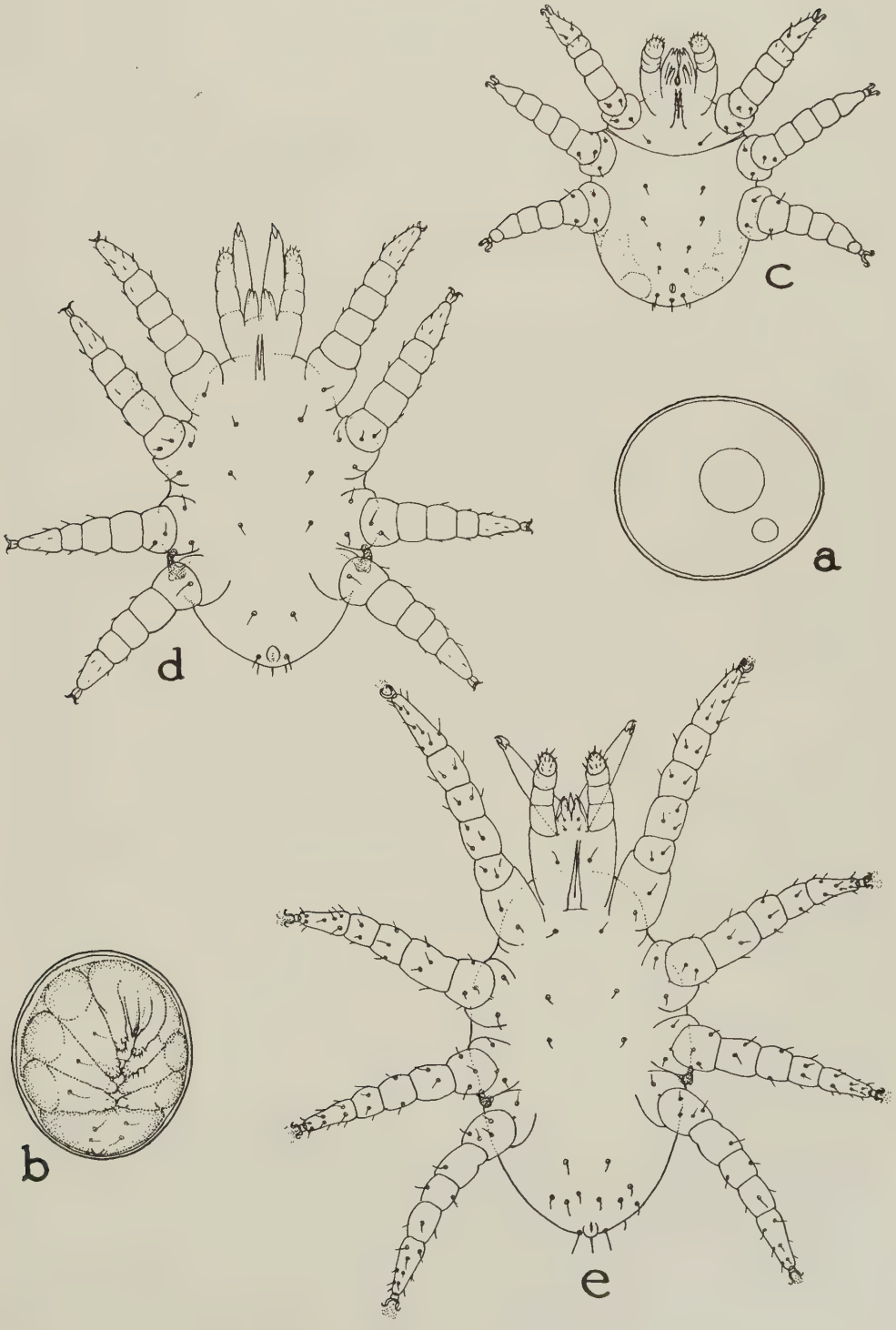


PLATE IV



ECTOPARASITE FAUNA OF SMALL MAMMALS AND BIRDS IN THE FUJI MANEUVER AREA, HONSHU, JAPAN[1]

WILLIAM SUYEMOTO,[2] JOHN E. SCANLON,[3] AND TEOFILO C. SICAY[4]

This report on the ectoparasite fauna of small mammals and birds in the Fuji maneuver area has resulted from an analysis of data assembled during 8 entomological surveys by the 406th Medical General Laboratory and the Far East Medical Research Unit, United States Army Forces, Far East.

The surveys have been limited geographically to but a small area northeast of Mt. Fuji, generally the same area as that surveyed in 1948 by Kuwata, Berge and Philip (1950). They were originally initiated to evaluate hazards from all arthropod pests present in this area, but with succeeding surveys it became increasingly apparent that the emphasis of field surveys should be restricted to parasites of small mammals and birds. An added incentive to this approach was the reported occurrence of scrub typhus cases among Army personnel on duty at Camp Fuji in the fall of 1948 (Anon., 1948, and Kuwata, *et al.,* 1950). The accessibility of the Fuji maneuver area made it possible to carry on extensive field investigations to permit adequate sampling of the ectoparasite fauna and animal reservoirs throughout the various seasons of the year. An attempt was made to determine the probable vector or vectors responsible for the 1948 outbreak of scrub typhus by studying the seasonal distribution and population of the chigger species during the course of the investigation.

Numerous individuals have participated in the field surveys leading to this report. In addition to the writers and Major Paul W. Oman, under whose general direction the project was undertaken, the following individuals have been engaged in this work: Sgt. Mariano F. Calpo, Cpl. Roy A. Crossman, Pfc William A. Drew, and Pfc Stanley G. Ennis.

The identification of ectoparasites has been made largely by the writers and we are indebted to Mr. F. G. A. M. Smit of Tring, England, for the identification of the female specimen of *Frontopsylla,* and to Dr. E. W. Jameson, Jr. for the identification of the male specimen of *Stenoponia montana.*

Identifications of mammal and bird hosts in this report have been made by Mr. Akiyoshi Nawa, taxidermist and adviser in mammology with this Department. The nomenclature used in listing mammalian hosts follows Kuroda (1953). Names of birds listed follow Shimomura (1942).

SCOPE OF THE SURVEYS

Chronologic. Surveys were scheduled to obtain adequate samplings of arthopod pests, vectors, and animal reservoirs of disease in the Camp Fuji maneuver area during each season of the year. During 1952 surveys were made during the periods 22–24 May, 26–30 August, 22–29 September, 7–11 October and 15–20 December.

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[1] From the Department of Entomology, 406th Medical General Laboratory, and the Far East Medical Research Unit.

[2] Entomologist, 406th Medical General Laboratory.

[3] 1st Lt., MSC, now at First Army Area Laboratory, New York.

[4] Capt., MSC, now at 6003rd A.S.U., US Army Hospital, Ft. Ord, California.

During 1953 surveys were made during periods of 26–30 January, 16–20 March and 4–12 May.

Geographic. The studies were limited to a relatively small region on the northeast slope of Mt. Fuji at elevations of approximately 2500 to 4000 feet. The northeastern limit of the survey was in the vicinity of the Higashiguchi trail, north of Camp Fuji. From this locality to about 300 yards beyond station No. 1 on the Gotembaguchi trail a number of selected areas were studied. Elevations above sea level for the areas studied are 2850 feet for Areas 2, 4, 5, 6, 8 and 10, 2870 feet for Area 3, 3040 feet for Area 7 and 4000 feet for Area 1.

Biologic. Principal effort was concentrated upon the ectoparasites of wild rodents, insectivores and birds in order to determine whether potential vectors of scrub typhus and other mite borne diseases were present and to determine by epidemiologic means, what vector species were responsible for the 1948 outbreak of scrub typhus among troops in the Fuji maneuver area.

Ecologic. Most of the region surveyed is rather uniformly covered with a thick layer of volcanic rock waste of soy bean size and smaller. The soil is generally shallow and in some sections exceedingly spotty. Deep soil is found only along the margins of some of the larger drainage courses. With the exception of Area 1, which is at an elevation of about 4000 feet and in the montane zone of vegetation, the vegetative cover of the areas is rather sparse excepting along the water courses. Area 1 is thickly wooded with *Abies, Quercus, Betula,* and *Acer,* with floor covering of moss, ferns and grasses. The remaining areas are more sparsely vegetated and characterized by extensive grassy sections, low deciduous shrubs, second growth hardwoods, and small wooded sections in which *Thuja, Cryptomeria,* and some *Pinus* predominate.

METHODS

Animal ectoparasites and their hosts. Various methods of collecting ectoparasites were used in the Fuji maneuver area, although the basic approach was to capture warm blooded hosts and examine them for the presence of parasites. Rodents and insectivores were trapped in representative ecologic habitats, and birds were shot wherever possible within the general area. Chiggers were collected during some of the surveys by the use of a black plastic plate laid on the ground to attract the chiggers, and during one survey trip chiggers were collected by using caged laboratory mice as "bait."

SURVEY RESULTS

Animal hosts. Animal hosts fell almost exclusively into three general categories, namely rodents, insectivores and birds. A total of 420 rodents, 83 insectivores, 64 birds and a lagomorph were taken during these surveys. By far the commonest rodent host taken was *Apodemus speciosus,* which occurred in all ecologic habitats explored. The next most abundant mammals were *Apodemus sylvaticus* and *Urotrichus talpoides,* both taken in virtually all habitats explored. *Microtus montebelli,* a vole, though not common, was taken most frequently in Areas 5 and 7. *Eothenomys smithii,* likewise relatively uncommon, was for the most part taken in Area 1 at an altitude of approximately 4000 feet. The birds most consistently encountered and collected were *Saxicola torquata stejnegeri, Chloris sinica minor, Emberiza fucata fucata, Passer montanus saturatus, Parus atricapillus restrictus,*

Parus major minor, Zanthopygia narissina narissina and *Zosterops palpebrosa japonica.*

Chiggers. A total of 16 species of chiggers representing four genera were recovered from rodents, insectivores, and birds (Suyemoto, 1953). Although not numerically abundant, some chiggers were encountered in all areas investigated. The average number of chiggers per host, based on collections from the four most abundant rodents and the one common insectivore, was 9.03. Of the 16 chigger species represented in the Fuji area, all occur on mammal hosts excepting *Neoschöngastia posekanyi,* which was found only on birds. Of the 27 species of birds examined, but 6 were infested with chiggers. Three species of chiggers, *Euschöngastia miyagawai, N. posekanyi,* and *Trombicula scutellaris* were found on birds, namely *Chloris sinica minor, Emberiza cioides ciopsis, E. fucata fucata, Parus major minor, Saxicola torquata stejnegeri, Troglodytes troglodytes fumigatus,* all of which live or feed on or near the ground. The mite plate sampling technic employed during and since the December survey resulted in the collection of 5 species of chiggers, namely *E. miyagawai, Trombicula fuji, T. pallida, T. scutellaris,* and *T. tamiyai.*

The seasonal occurrence of chiggers in the Camp Fuji area indicates that most species involved fall into the so-called "winter" group, as determined by time of occurrence of the parasitic larval stage, with the questionable exceptions of *T. nagayoi* and *N. posekanyi.* These were the only species encountered during the August survey when the number of chigger specimens were exceedingly low. The paucity of our data concerning these two species does not permit generalizations as to whether they can be rightfully assigned to the "summer" group of chiggers. Within seasonal limitations the appearance of larval trombiculids apparently tends to be influenced by weather conditions. With respect to the "winter" group as a whole, the accumulated data indicate that from approximately the end of May the larval trombiculid population on rodents declines rapidly until the advent of cooler weather sometime during September, when the population again increases. Fortuitously, it was possible to "pinpoint" the autumn rise in chigger population during the September field survey. During the course of this field trip, very few chiggers were found on rodents on the first days of trapping. Only 14 chiggers were taken from 54 rodents during the period 23 through 26 September, 1952. A heavy rainfall began on the night of 25 September and continued through 26 September. Beginning 27 September chiggers were abundant in all areas surveyed. *T. scutellaris* was the predominant species in all areas trapped and at that time was also recovered from a bird. The chiggers taken at this time were for the most part unengorged, indicating recent attachment, and many were found on hosts but unattached. During December, January and March, chiggers were recovered by use of mite plates when air temperature was as low as 3° C. During the January survey one specimen of *E. miyagawai* was taken from a plate placed on the ground after brushing aside a 3 to 4 inch layer of snow.

The distribution of chiggers in the various areas surveyed revealed that but 1 of the *Leptotrombidium* chigger group, *T. fuji,* was taken in Area 1, elevation about 4000 feet, even though *T. pallida, T. scutellaris* and others were common at the lower elevations. *T. fuji,* in particular, has been found commonly throughout the Kanto plain area and is common to all areas surveyed in the Fuji maneuver area. By way of contrast, *T. nagayoi* has been found only on Hokkaido and in the higher

elevations of central Honshu. With this exception, there have as yet been no significant distribution patterns detected for the chiggers in the Fuji area. The abundance of chiggers in a given locality appears to be rather closely correlated with the abundance of their rodent hosts, which in turn is influenced by suitable terrain, these animals being more abundant in sections where the soil is fairly deep and vegetative cover luxuriant. Even within an area known to have a high population of chiggers, their distributon appears to be exceedngly spotty, as determined by the plate sampling method.

The disease vector suspects among the chiggers present in the Camp Fuji area are those belonging to the subgenus *Leptotrombidium,* namely *T. fuji, T. kitasatoi, T. pallida, T. palpalis* and *T. scutellaris.* On the basis of data accumulated during our surveys, and assuming that the findings are typical with respect to seasonal occurrence, *T. scutellaris* (known to harbor rickettsiae, Kawaji *et al.,* 1953), is a suspected vector during late September and October, the period during which the scrub typhus cases of 1948 must have been contracted. *T. pallida,* which was present from September to May, is also a suspected vector. The absence of *T. kitasatoi* in September and the occurrence of but one specimen during the October survey, and *T. palpalis,* which is definitely a winter species, would all be excluded from the role of a potential disease vector in connection with the 1948 scrub typhus outbreak. Although definite proof is lacking, it seems unlikely that *T. fuji* can serve as a vector because of its absence in September and its low level of larval population during October, reaching its population peak in December. During the October survey, *T. fuji* occurred at elevations below 2870 feet and it was conspicuously absent from Areas 1 and 7 utilized to a large extent by troops on field maneuvers. Fukuzumi, Obata and Kagiwada (1951) isolated the etiologic agent of scrub typhus from the rodent, *Apodemus speciosus,* and showed by laboratory experiments that *T. pallida* is capable of transmitting the disease, but to date positive proof of the local vector mite is lacking. These studies have served to demonstrate that chiggers are most abundant in the survey area during the fall and winter months, and active at relatively low temperatures. The spotty distribution of chiggers in infested areas makes it impracticable clearly to define "danger areas" and "non-danger areas." The avoidance of chigger attacks, and hence of chigger-borne diseases, would appear to depend largely upon the observance of personal protective measures during the seasons when chiggers are known to be present. Fortunately the standard U. S. Army clothing treatment repellents are effective acaricides, and if used properly can be expected to give good protection. This measure should be supplemented, whenever possible, by avoidance of intimate contact with the ground in infested areas.

Laelaptid mites. Ten species of laelaptid mites were taken from rodents and insectivores. The species most consistently encountered were *Laelaps jettmari* and *Haemogamasus japonicus.* It is of interest to note that *Laelaps* sp. encountered primarily on *Clethrionomys rufocanus* on Hokkaido has been found rather frequently in the Fuji area on *Eothenomys smithii.* In addition, *Neoichoronyssus isabellinus* previously reported in Japan only from Hokkaido occurs also in the Fuji maneuver area. Among the laelaptid mites encountered in the Fuji area, none thus far has been incriminated as a vector of any known disease in Japan.

Lice. Six species of blood-sucking lice, all members of the genera *Hoplopleura*

and *Polyplax,* were collected during the Fuji survey. Inasmuch as the Anoplura complete their life cycle entirely upon the host animal and are relatively host specific (Ferris and Stojanovich, 1951), their distribution within the survey area is coupled with the distribution of the host species and only indirectly with the terrain or other factors. Wherever the proper hosts were taken in numbers sucking lice were collected. Furthermore, lice were collected during all seasons of the year and no particular population trends were detected.

The most frequently collected species were *Hoplopleura affinis* and *Polypax serrata.* Both were recovered from hosts of the genus *Apodemus* and are normally parasites of rodents of this genus. The two species of lice were found on single host animals several times. *Microtus montebelli montebelli* was infested with *Hoplopleura acanthopus* and *Polyplax abscisa,* but the two lice species were not found in multiple infestations of individual hosts. The same was true of the species of lice infesting *Micromys minutus,* namely *Hoplopleura longula* and *Polyplax gracilis.* The latter species is apparently quite rare as it has not been reported since the original description in 1910 from the same host, probably collected in Germany (Fahrenholz, 1910). The Fuji specimens agree well with original and subsequent descriptions. Further notes on these specimens and additional material from Korea have been prepared for presentation elsewhere.

Of particular interest is the absence of Anoplura from *Urotrichus talpoides* in view of the large number of hosts examined. On the contrary the apparent absence of lice from the shrews, *Crocidura russula* and *Sorex caecutiens* is probably due to the small number of animals examined rather than to an absence of lice. The same may be said of the Japanese dormouse, *Glirulus japonicus,* and the rabbit, *Lepus brachyurus.*

The species of lice collected in the Fuji area pose no particular problem in the causation of human disease. Rodent lice have been implicated as rodent to rodent vectors of murine typhus and must be suspected in this role wherever a rodent-borne disease is encountered. But the possibility of these lice being involved in natural rodent to man transmission of disease is extremely remote inasmuch as the rodent-infesting lice will not attack man under natural conditions.

Fleas. Although only small numbers of SIPHONAPTERA were encountered during the course of the surveys, a total of 9 species were taken from rodents and insectivores. The species encountered most frequently was *Paleopsylla nippon* taken primarily from shrew-moles in practically all areas surveyed. *Frontopsylla* sp. recovered from *Apodemus speciosus* for the first time from Japan is of interest historically from an evolutionary viewpoint. The known *Frontopsylla* species of the family CERATOPHYLLIDAE reported from European birds presents an example of convergent evolution (Rothschild and Clay, 1952). *Stivalius* sp. "A" was common only during the summer months. *Stivalius ahalae* from South India and *St. cognatus* from Java are of medical importance in that they are involved in the transmission of bubonic plague. In view of the 1907 plague epidemic in Japan, the possibility of future outbreaks cannot be ignored. This species might well serve as a vector should sylvatic plague become established in Japan.

SUMMARY

Sixteen species of chiggers, belonging to 4 genera, are known to occur in the Fuji military maneuver area. On the basis of seasonal occurrence 2 of these species,

namely *Trombicula pallida* and *T. scutellaris,* qualify as possible vectors during the 1948 outbreak of scrub typhus in this area. Chiggers were scarce, both in number of species and individuals, during the summer months, as shown by surveys in 1952 and 1953, and did not become abundant until late September. No significant distribution pattern is detected for the chiggers in the Fuji maneuver area with the exception of *Trombicula nagayoi* which occurs at relatively high elevation. Protection from the hazards of chigger-borne diseases depend upon use of clothing impregnated with acaricides and avoidance of intimate contact with the ground in infested areas. Chiggers are the only ectoparasites collected during the series of survey trips which may be considered to be medically important.

References Cited

Anonymous 1948 A new endemic area of tsutsugamushi disease in Japan. 406th Med. Gen. Lab., Ann. Hist. Rep. for 1948, pp. 90–99.

Fahrenholz, H. 1910 Diagnosen neuer Anopluren. Zool. Anz. **35**: 714–715.

Ferris, G. F. and Stojanovich, C. J. 1951 The sucking lice. Mem. Pac. Coast Ent. Soc. 1–320.

Fukuzumi, S., Abata, Y. and Kagiwada, R. 1951 On the trombiculid mite and Rickettsia discovered in the Mt. Fuji foot plain. Kitasato Arch. of Exp. Med. **23** (4): 12–14 (in English).

Kawaji, T., Benoki, M., Hata, K., Imazono, Y., Hirotani, F., Kawamura, A., Oda, A., Kasahara, S., Ishida, K., Fukuzumi, S., Obata, Y., Kitaoka, M., Okubo, K., Takemori, N., Shishido, A., Takano, K., Ogata, T., Otowara, M. and Taniguchi, H. 1953 On the causative agent of so-called "Shichito" fever. "Studies on Shichito Fever." Section of Prevention, Dept. of Pub. Health, Tokyo-to, pp. 110–115 (in English).

Kuroda, N. 1953 A monograph of the Japanese mammals. 1–176 pp. Sogen-sha Co., Tokyo, Japan (in Japanese).

Kuwata, T., Berge, T. O. and Philip, C. B. 1950 A new species of Japanese larval mite from a new focus of tsutsugamushi disease in southeastern Honshu, Japan. J. Parasit. **36**: 80–83.

Rothschild, M. and Clay, T. 1952 Fleas, Flukes and Cuckoos. A study of bird parasites. New York, N. Y.: Philosophical Library, Inc., 1–304 pp.

Shimomura, K. 1942 A monograph of Wild Birds. i–ii, 1–163 pp. Sanshodo Co., Tokyo, Japan.

Suyemoto, W. 1953 Chiggers in the Fuji Maneuver Area. USAFFE Med. Bull. **1** (11): 198–200.

INTERNAL PARASITES IN NORTH DAKOTA ANTELOPE[1]

Alice I. Goldsby[2]

and

D. F. Eveleth

Department of Veterinary Science, North Dakota Agricultural College, Fargo, North Dakota

The largest herd of antelope in the western part of the United States is located in an area comprising parts of Montana, Wyoming, and North and South Dakota. Some antelope spend their summers in North Dakota and migrate into adjoining states during the fall and winter.

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[2] Present address: Department of Veterinary Science, University of Wisconsin, Madison, Wisconsin.

For years they have been protected in North Dakota because of their scarcity; consequently, when a number of permits were issued for hunting antelope in two areas in southwestern North Dakota, the opportunity was seized to examine them for parasites and other diseases. The work was undertaken to determine the interrelation of diseases of domestic and wild animals.

During September, 1951, 95 sets of small and large intestines and 59 abomasums of pronghorn antelope (*Antilocapra americana*) were collected and examined for parasites. Members of the Veterinary Science Department of the North Dakota Agricultural College, Fargo, North Dakota and of the Game and Fish Department, Bismarck, North Dakota, worked cooperatively in the field to collect the specimens. The intestines and abomasums were brought to this laboratory for parasitological studies while the Game and Fish Department took the rumens for food habit studies.

METHODS

The gastrointestinal tracts were collected as the hunters eviscerated their animals and placed in sufficient 10% formalin for proper fixing. In the laboratory the abomasums and small and large intestines were opened, the mucosa rinsed to remove all clinging helminths and the contents of each washed until clear in a sieve (mesh opening 0.25 mm.). The sieve retained all immature and adult helminths known to infect ruminants. Larvae just emerging from the ova might have escaped.

The number of parasites present was determined by a dilution method; if large numbers were involved the dilution was increased up to 8 liters. If no helminths were found upon dilution, all of the sediment was examined. Parasites which were low in incidence were possibly overlooked by this method.

The genera *Nematodirella* and *Nematodirus* were counted as a group, as were the small nematodes of the abomasum. From observations it seemed that the first mentioned group consisted almost entirely of *Nematodirella*. All specimens were stained with Semichon's acetic carmine and mounted in glycerine. Photomicrographs were taken through a phase microscope.

RESULTS

Degree of parasitization

Nine genera comprising 15 species were represented in the antelope. The maximum and average number, and percent of infection for each species found in the gastrointestinal tract are given in Table 1.

The largest number of nematodes found in the intestines of an antelope (for which the abomasum was not available) was 6411, of which 5886 were immature. The majority of these belonged to the genera *Nematodirus* and *Nematodirella*. Ninety percent of the antelope examined were infected with these two genera; 5 carried a load of over 3000; 5 between 2000 and 3000; 23 between 1000 and 2000 and 53 less than 1000. Thirty-six animals harbored immature *Nematodirus* and *Nematodirella*, 33 harbored less than 100, 2 above 100 and one above 4,000.

The largest number of *Ostertagia* and *Pseudostertagia* nematodes occurring in any one animal was 739. One antelope had an infection of 748, one of 348, one of 256, 10 between 100 and 200, 15 between 21 and 88, and 4 had 3 or less.

TABLE 1.—*Helminths found and percentage of infected gastrointestinal tracts of North Dakota antelope*

Parasite	Maximum number of worms	Average number of worms per antelope examined	Percent of gastrointestinal tracts parasitized
*Haemonchus sp.**	448	34	51
Ostertagia sp.	739	75	54
Nematodirus and *Nematodirella spp.*	3787	862	91
Capillaria sp.	1	0**	1
Cooperia sp.	315	14	15
Trichostrongylus sp.	50	0**	1
Moniezia sp. (in grams)	201	0**	7
Immature nematodes	1970	192	38
Trichuris sp.	3	0**	4

* Of 59 abomasums examined (30 of these showing *Haemonchus*), 9 had lesions ascribed to this species.
** Average less than 1.

The highest numbers of *Haemonchus contortus* present were 448, 292, 256, 152, 126 and 121. Six antelope were infected with from 54 to 80 of these stomach worms, 5 with 12 to 27, and 13 with 12 or less.

The average number of *Haemonchus, Ostertagia* and *Pseudostertagia* found was influenced greatly by the large numbers which occurred in only a few of the animals.

Although the numbers of *Haemonchus, Ostertagia* and *Pseudostertagia* were relatively high in a few of the antelope, none of them carried a parasite load that Swales (1940) considered as harmful to sheep.

Upon laboratory examination, the small intestines of two of the antelope were sufficiently impacted with tapeworms to produce a mechanical interference with the passage of chyme (Fig. 1). Nine of the 59 abomasums examined showed lesions which were presumably produced by *Haemonchus contortus* parasites (Fig. 2). The stomach lesions were present in both young and old animals.

No differences were observed in the parasite load in relation to weight or age of animal.

Gross examination in the field showed all of the antelope to be in good flesh. No evidence of ectoparasitism or infectious disease was observed.

The antelope from which the viscera were taken were killed in two areas in southwestern North Dakota. One area, predominantly cattle range, was located in parts of Golden Valley and McKenzie Counties. The other area, predominantly sheep range, was located in parts of Bowman and Slope Counties. A comparison

TABLE 2.—*Comparative number of helminths found and percentage of infected gastrointestinal tracts of antelope killed in cattle and sheep ranges**

Parasite	Average number of worms per antelope examined		Percent of gastrointestinal tracts parasitized	
	Cattle range	Sheep range	Cattle range	Sheep range
Haemonchus sp.	12	49	5	68
Ostertagia sp.	19	74	37	63
Nematodirus and *Nematodirella spp.*	1022	788	100	80
Cooperia sp.	13	11	16	17
Trichuris sp.	0**	0**	3	3
Moniezia sp. (in grams)	none	0**	none	11
Immature nematodes	140	82	40	38

* Eight abomasums and 30 intestines were from antelope killed in cattle country, while 22 abomasums and 26 intestines were from antelope killed in sheep country. Only 30 of the 59 abomasums and 56 of the 95 intestines examined were identified as to location.
** Average less than 1.

of the number of helminths and the percent of animals found infected on cattle and sheep range is given in Table 2.

When the parasite loads of the antelope taken from these two areas are compared, the sheep range group is seen to have higher percentages of infection and higher average counts in the *Haemonchus, Ostertagia* and *Pseudostertagia* groups, while the cattle range group is highest in percentage of infection and average counts for the *Nematodirus-Nematodirella* group, the *Cooperia* and immature parasites. The other genera of parasites were present in small numbers and differences would not be significant.

Species identified

Records of the occurrence and geographic location of antelope helminths are scattered. These published records are reviewed below, along with the species of helminths identified in North Dakota antelope.

According to measurements given by LeRoux (1929), Olsen and Fenstermacher (1943), and Ransom (1911) of the length of spicules and spicule barbs the species found by us in the North Dakota antelope was *Haemonchus contortus* (Fig. 3). Ransom (1911) listed the pronghorn antelope (unspecified whether captive or wild) as a host to this parasite, and Lucker and Dikmans (1945) reported collections from wild antelope for the first time in South Dakota.

Three species of small abomasal parasites, *Pseudostertagia bullosa, Ostertagia ostertagi* and *O. circumcinta,* were in sufficient numbers for definite identification. Only one young male specimen of a fourth species appeared in the collection. According to spicule structure, this parasite should fall under *O. bisonis,* as described by Chapin (1925). The parasite collected here is 5.8 mm. long. Pointing inward and 45 microns from the posterior ventral end of each 150 micron spicule, appears a small boss. The right spicule ends in a corkscrew hook. Each spicule also has two quite transparent pointed posterior processes. No gubernaculum is present. Neither *O. bisonis* nor *P. bullosa* has been reported as North Dakota parasites, nor did Dikmans (1939) list *O. bisonis* from antelope.

Ostertagia circumcinta (Figs. 4 and 8) was listed as an antelope parasite by Ransom (1911), and as present in North Dakota by Eveleth and Goldsby (1945). *O. ostertagi* (Figs. 5 and 9) has been tentatively identified as a parasite of North Dakota cattle by ova count (Goldsby, 1952). It has not been previously identified as a parasite of antelope.

Ransom and Hall (1912) reported *Pseudostertagia bullosa* (Figs. 6, 7 and 10) as a new species from Colorado and Montana sheep. Lucker and Dikmans (1945) established its presence in South Dakota antelope from specimens collected by Dr. Irving H. Roberts. Lucker and Dikman's suggestion that *P. bullosa* is normally a parasite of wild antelope has support in our data since *P. bullosa* has not been found in North Dakota sheep (Eveleth and Goldsby, 1945), and since the numbers of the various *Ostertagia* species present here showed *P. bullosa* to be dominant. Lucker and Dikmans also reported that Dr. Lee Seghetti collected *P. bullosa* from antelope in Montana.

Nematodirella longispiculata antilocaprae (Figs. 11 and 12) was the most prevalent helminth in the antelope. Olsen and Fenstermacher (1942) found this to be true of moose in Minnesota. This variety of *Nematodirella* with the shorter spicule was first described by Dikmans (1935). Price (1927) reported *Nemato-*

dirus antilocaprae from captive antelope, but Dikmans (1933), on re-examining the specimens, found them synonymous with *N. longispiculata.* This species has not been previously listed as a North Dakota parasite.

One male *Nematodirus spathiger* (Fig. 13) and two male *N. filicollis* (Fig. 14) were collected. Lucker and Dikmans (1945) reported *N. spathiger* for the first time with wild pronghorn antelope under natural conditions, and Travassos (1937) listed *N. filicollis* from antelope.

Only one species of *Trichostrongylus,* namely *T. colubriformis* was found, and this occurred only in small numbers. It had previously been collected by Roberts in 1944 (Lucker and Dikmans, 1945) from antelope in South Dakota. *T. colubriformis* has been observed as a frequent parasite of North Dakota sheep.

Cooperia oncophora and *bisonis* occurred in small numbers. This appears to be the first report of *C. oncophora* (Figs. 17 and 18) from antelope. *C. bisonis* (Figs. 15 and 16) was collected for the first time from wild antelope in South Dakota in 1944 (Lucker and Dikmans, 1945). It was originally described by Cram (1925) as a parasite infecting *Bison bison* in Canada. *C. bisonis* has not been previously reported as being present in North Dakota.

One female *Capillaria* specimen was collected. The measurements of this parasite (length 13.5 mm., vulva located 7.3 mm. from the posterior extremity, ova 100 by 60 microns) are similar to those given by *C. brevipes* by Ransom (1911). Of the three *Capillaria* species listed by Ransom, *C. brevipes* is the only species this small. It has not been reported in antelope or in North Dakota previously.

The two species of *Moniezia,* while common in sheep and cattle in America, have not been previously reported from antelope. Segments containing the rounded interproglottid glands which spread across the posterior portion of the segment and triangular ova of *M. expansa* were observed, as well as segments with the linear interproglottid glands which were limited to the central posterior area and the more or less square ova of *M. benedeni.*

Trichuris sp. was the only helminth found in the lower intestines. Due to the fact that no males were present, it was difficult to determine the species. They were probably *T. ovis.*

SUMMARY

Ninety-seven percent of 95 southwestern North Dakota antelope were parasitized with helminths as determined by examinations of 95 intestines and 59 abomasums. The degree of parasitism ranged from 6 to 6614 worms.

The parasite load seemed to vary with the habitat of the antelope. Those in ranges grazed by sheep had more abomasal parasites while those on ranges grazed by cattle had more intestinal worms. Nine genera and 15 species were represented. Of these, *O. ostertagi, O. bisonis, C. oncophora, C. brevipes, M. expansa* and *M. benedeni* are reported for the first time from wild pronghorn antelope. *P. bullosa, O. bisonis, N. longispiculata antilocaprae, C. bisonis* and *C. brevipes* are reported for the first time from North Dakota.

ACKNOWLEDGMENTS

We wish to thank Doris Hanson and the members of the North Dakota Game and Fish Department for their help in the collection and preparation of materials.

Thanks are also due Dr. F. M. Bolin for aid in collection of specimens and for making post mortem examinations of a number of antelope carcasses in the field.

Literature Cited

Chapin, E. A. 1925 New nematodes from North American mammals. J. Agric. Research **30**: 677–681.

Cram, E. B. 1925 *Cooperia bisonis*, a new nematode from buffalo. J. Agric. Research **30**: 571–573.

Dikmans, G. 1933 *Antilocapra americana* an additional host of *Nematodirella longispiculata*. J. Parasit. **20**: 107.

———1935 A note on Nematodirella (Nematoda: Trichostrongylidae) from three different hosts. Proc. Helminth. Soc. Washington, **2**: 58–59.

———1939 Helminth parasites of North American semidomestic and wild ruminants. Proc. Helminth. Soc. Washington, **6**: 97–101.

Eveleth, D. F. and Goldsby, A. I. 1945 The gastrointestinal parasites of sheep in North Dakota. Vet. Med. **40**(3): 90–96.

Goldsby, A. I. 1952 Internal parasites in North Dakota cattle. N. D. Agric. Exper. Sta. Bimonthly Bulletin **14** (5): 203–204.

Le Roux, P. L. 1929 A preliminary report on three new members of the genus Haemonchus (Cobb 1898) from antelopes in South Africa. 15th Ann. Report. Director Vet. Serv., Dept. Agric. Union South Africa **1**: 451–463.

Lucker, J. T. and Dikmans, G. 1945 The distribution of *Pseudostertagia bullosa* and some new records of nematodes from pronghorn antelope (*Antilocapra americana*). Proc. Helminth. Soc. Washington **12**: 2–4.

Olsen, O. W. and Fenstermacher, R. 1942. Parasites of moose in Northern Minnesota. Am. J. Vet. Research **3**: 403–408.

——— and ——— 1943 The helminths of North American deer with special reference to those of the white-tailed deer (*Odocoileus virginianus borealis*) in Minnesota. Tech. Bull. 159 Uni. Minn. Agric. Exper. Station, 20 pp.

Price, E. W. 1927 A new nemotode *Nematodirus antilocaprae* from the pronghorn antelope with a key to the species of *Nematodirus*. Proc. U. S. Nat. Mus., Wash. 71, Art. 22, pp. 1–4

Ransom, B. H. 1911 The nematodes parasitic in the alimentary tract of cattle, sheep and other ruminants. Bull. 127, Bureau of Animal Industry, U. S. Dept. of Agric. 132 pp.

———and Hall, M. C. 1912 A nematode, *Ostertagia bullosa*, parasitic in the alimentary tract of sheep. Proc. U. S. Nat. Mus. (1892) **42**: 175–179.

Swales, W. E. 1940 The helminth parasites and parasitic diseases of sheep in Canada. I. A survey and some preliminary studies on existing problems. Canad. J. Research **18**, Sect. D: 29–48.

Travassos, L. 1937 Revisão da familia Trichostrongylidae Leiper, 1912. Monogr. Inst. Oswaldo Cruz (1), 512 pp.

Explanation of Plates

The gross specimens photographed were fixed in 10% formalin immediately upon the death of the animal. All photomicrographs are of specimens fixed in 10% formalin, stained with acetic carmine, and taken with the aid of a phase microscope.

Plate I

Fig. 1. Intestine of an antelope infected with *Moniezia* sp.
Fig. 2. Antelope abomasum pinpointed with lesions presumably caused by *Haemonchus contortus.*
Fig. 3. Bursa and spicules of male *Haemonchus contortus.* Note barbs in posterior area of spicules.

Plate II

Fig. 4. Region of vulva and vulva flap of female *Ostertagia circumcinta.* Note stubby vulva flap.
Fig. 5. Region of vulva and vulva flap of female *Ostertagia osteragi.* Note wrap around vulva flap.
Fig. 6. Region of vulva of female *Pseudostertagia bullosa.* Note absence of vulva flap.
Fig. 7. Region of anus of female *Pseudostertagia bullosa.* Note swelling of cuticle in anal region.

Plate III

Fig. 8. Bursa area of male *Ostertagia circumcinta.*
Fig. 9. Bursa area of male *Ostertagia ostertagi.*
Fig. 10. Bursa area of male *Pseudostertagia bullosa.* Note cuticular swelling just anterior to bursa.

Plate IV

Fig. 11. Body constriction in vulva area of female *Nematodirella longispiculata antilocaprae.*
Fig. 12. Bursa area of *Nematodirella longispiculata antilocaprae.*
Fig. 13. Bursa region of *Nematodirus spathiger.* Note spoon-like spicule ending.
Fig. 14. Bursa region of *Nematodirus filicollis.* Note straightness of posterior extremity of spicules as compared to those of *Nematodirus spathiger.*

Plate V

Fig. 15. Vulva region of *Cooperia bisonis.* Note large vulva flap.
Fig. 16. Bursa region of male *Cooperia bisonis.* Spicules in upper right hand corner.
Fig. 17. Vulva region of *Cooperia oncophora.*
Fig. 18. Bursa region of *Cooperia oncophora.*

PLATE I

PLATE II

PLATE III

PLATE IV

PLATE V

AN UNUSUAL AND HEAVY INFECTION OF A PRAWN, *PANDALUS BOREALIS* KRØYER, BY A NEMATODE, *CONTRACAECUM* SP.

L. Margolis and T. H. Butler

Pacific Biological Station,
Fisheries Research Board of Canada,
Nanaimo, British Columbia.

A *Pandalus borealis* Krøyer, caught off Point Grey, Vancouver, British Columbia, on March 23, 1949 was infected with more than 100 individuals of a species of the nematode genus *Contracaecum* Railliet and Henry, 1912. The prawn was alive at the time of capture. Initial examination revealed a number of nematodes protruding conspicuously from under the carapace. Upon subsequent dissection

Text Fig. 1.—Photograph of *Contracaecum* infected prawn, after formalin fixation. The mass of nematodes at the bottom came from the prawn.

Text Fig. 2.—Enlargement of anterior region, with carapace removed, of prawn shown in Text Fig. 1.

they were found in the haemocoel and embedded in the musculature of the abdomen (Text figures 1 and 2). There was no indication of encystation or tissue reaction on the part of the host. The whole animal, with its parasites, was fixed by dropping into cold formalin. During this procedure, many of the nematodes wriggled free of the prawn. These are the worms in the tangled mass at the bottom of text figure 1. Unfortunately a photograph of the fresh prawn was not taken.

There is some evidence to suggest that the heavy parasitic load interfered with or delayed egg production by the prawn. Practically all female *P. borealis* examined at the same time as the parasitized specimen were ovigerous. The infected female was not ovigerous and there was no evidence that the ova had recently hatched.

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The following description of the nematode is based on examination of 11 mature and one immature males and 15 mature and 4 immature females. The measurements include the smallest and largest males and females encountered.

Description: Body variable in size, fairly stout. Maximum width about two-thirds from anterior end, tapering gradually anteriorly and more abruptly posteriorly. Females larger than males. Cuticle finely striated, striations 4–6 microns apart. Lateral cuticular alae narrow (Plate I, fig. 6).

Three large lips (Plate I, figs. 1–5) of about equal size (dorsal lip sometimes slightly shorter than ventro-lateral lips), roughly hexagonal in outline, about as long as wide, with wide triangular cuticular expansions. Lip peduncles narrower than anterior margin of lips. From peduncle, lip pulp widening anteriorly, more so in dorsal than ventro-lateral lips. Pulp bearing two lobed anterior projections. Anteriorly, on inner surface, cuticular lining of lips forming a series of interlocking ridges and depressions. Two large papillae present at antero-lateral margins of pulp of dorsal lip. One large papilla anteriorly and ventral to median line of ventro-lateral lips; amphid at antero-lateral corner. Interlabia (Plate I, figs. 1, 2, 5) roughly triangular in outline, usually somewhat less than one-half length of major lips.

Esophagus claviform. Ventriculus roughly spherical. Intestinal cecum usually between one-third and one-half length of muscular esophagus, and usually longer than esophageal appendix (as much as twice its length), but occasionally equal to or shorter than latter organ (Plate II, fig. 9).

Tail, shorter in male than female, conical, with retractile tip bearing small spines. Three large rectal glands at proximal end of rectum.

Mature males: 24.8–65 mm. long, 0.46–1.22 mm. maximum breadth ($\alpha^1 = 50–60$). Width

$$^1\alpha = \frac{\text{body length}}{\text{body width}}.$$

of body at base of lips and at posterior end of esophagus, 0.18–0.35 mm. and 0.38–0.78 mm., respectively. Lips 0.13–0.27 mm. long, 0.13–0.28 mm. wide. Peduncles of lips 0.059–0.100 mm. wide. Interlabia 0.056–0.120 mm. long.

Muscular esophagus 2.4–5.0 mm. long, 0.18–0.35 mm. maximum width ($\beta^2 = 9.3–14.1$).

$$^2\beta = \frac{\text{body length}}{\text{esophageal length}}.$$

Ventriculus 0.15–0.28 mm. by 0.15–0.35 mm. Intestinal cecum 1.01–2.30 mm. long, 0.18–0.33 mm. maximum width. Esophageal appendix 0.62–1.26 mm. long, 0.10–0.17 mm. maximum width.

Excretory pore 0.70–1.22 mm. from anterior extremity. Nerve ring 0.08–0.26 mm. anterior to pore.

Tail (Plate II, figs. 7, 8) curved ventrad, 0.11–0.18 mm. long, relatively shorter in the longer specimens ($\gamma^3 = 246–382$).

$$^3\gamma = \frac{\text{body length}}{\text{tail length}}.$$

Prominent anterior cloacal lip. Twenty-seven to 34 pairs pre-cloacal papillae increasing in size and becoming more laterally placed anteriorly; extending almost to union of ejaculatory duct and seminal vesicle in large specimens and anterior (thereto) in small specimens. Four pairs post-cloacal papillae, anterior-most smallest and often difficult to see. Spicules equal, 2.0–3.7 mm. long (1/14–1/18 of body length), with four elongate-oval glands at proximal extremity. Ejaculatory duct 1.6–3.7 mm. long. Seminal vesicle 2.9–15.2 mm. long. Testis much convoluted and extending far forward.

Immature male: 22.0 mm. long, maximum width 0.38 mm. ($\alpha = 58$). Esophagus, ventriculus, intestinal cecum and esophageal appendix, 2.5 mm. by 0.15 mm., 0.15 mm. by 0.15 mm., 0.98 mm. by 0.15 mm. and 0.87 mm. by 0.08 mm., respectively ($\beta = 8.8$). Lips of adult type, 0.10 mm. long; interlabia 0.045 mm. long. Excretory pore and nerve ring 0.63 mm. and 0.50 mm. from anterior end. Tail 0.13 mm. long ($\gamma = 169$). Spicules and caudal papillae not visible.

Mature females: 43.5–83.9 mm. long, 0.76–1.69 mm. maximum breadth ($\alpha = 45–59$). Body width behind lips and at level of ventriculus, 0.29–0.50 mm. and 0.57–1.15 mm., respectively. Lips 0.25–0.41 mm. long, 0.25–0.42 mm. wide. Peduncles of lips 0.09–0.17 mm. wide. Interlabia 0.098–0.180 mm. long.

Muscular esophagus 3.50–6.48 mm. long, 0.27–0.50 mm. maximum width ($\beta = 10.9–13.9$). Ventriculus 0.21–0.42 mm. maximum breadth. Esophageal appendix 0.75–1.73 mm. long, 0.12–0.29 mm. maximum width.

Excretory pore 0.85–1.26 mm. from anterior extremity. Nerve ring 0.06–0.21 mm. anterior to excretory pore.

Tail (Plate II, fig. 11) 0.35–0.57 mm. long ($\gamma = 120–183$). Rectum 0.41–0.59 mm. long.

Vulva (Plate II, fig. 10) 14.8–29.5 mm. (or 29.8–39.0% of body length) from anterior extremity. Vagina, extending posteriorly from vulva, 5–7.5 mm. long, somewhat sinuous or with one to several loops along its length, joining posteriorly directed single branch of uterus, 5–9.6 mm. long, giving rise to two parallel uterine branches, 5.8–13.2 mm. long, also posteriorly directed. Each uterine branch joining oviduct, latter almost immediately looping back anteriorly to level of vulva or a short distance anterior to it, then turning back on itself, becoming much convoluted and joining the coiled ovary. Ova, 49.8–57.4 microns by 47.6–51.5 microns, in morula stage when deposited.

Immature females: 21.3–35.0 mm. long, 0.35–0.60 mm. maximum width ($\alpha = 52.3–58.3$). Lips as in adults, 0.10–0.19 mm. long. Interlabia 0.060–0.091 mm. long. Esophagus, ventriculus, intestinal cecum and esophageal appendix, 2.38–3.40 mm. by 0.18–0.24 mm., 0.12–0.21 mm. by 0.17–0.23 mm., 0.87–1.51 mm. by 0.17–0.28 mm. and 0.56–1.01 mm. by 0.09–0.14 mm., respectively ($\beta = 7.9–10.3$). The intestinal cecum in the 35 mm. specimen is extremely short, measuring only 0.45 mm. in length (about 1/8 the length of the esophagus and 2/3 the length of the esophageal appendix). Excretory pore and nerve ring 0.63–0.85 mm. and 0.56–0.68 mm. from anterior extremity. Tail, 0.28–0.40 mm. long ($\gamma = 60–101$). Rectum 0.21–0.34 mm. long. Vulva not evident in specimens of 21.3 and 24.5 mm. length. Vulva in specimens 26.3 and 35.0 mm. long located 10.2 and 11.8 mm., respectively, from anterior end. Ova not present in these specimens.

Maturity apparently taking place in males between the lengths of 22.0 and 24.8 mm., and in females between 35.0 and 43.5 mm.

In attempting to identify the nematodes, much difficulty was encountered. More than fifty species of the genus *Contracaecum* have been named. The diagnosis or descriptions and illustrations of many of them, particularly the earlier known species, are extremely poor and it is apparent that some of the named species are synonymous. The present specimens bear a very close resemblance to *Contracaecum aduncum* (Rudolphi, 1802) and *Contracaecum clavatum* (Rudolphi, 1809) (? = *gadi* Müller, 1776) from marine fishes. Punt (1941), after completing a very detailed study of *Contracaecum* in fishes of the North Sea, suggested that these two species are actually identical. Since good descriptions of the type specimens are nonexistant the problem remains unsettled and there is considerable controversy with reference to the concept of these two species. Recent descriptions and discussions of *C. aduncum* and *C. clavatum* (? = *gadi*) are to be found in Markowski (1933), Kahl (1936), Punt (1941), Kreis (1952), Dollfus (1952) and Shulman and Shulmanova-Albova (1953).

According to H. A. Baylis (in Dollfus (1952, p. 197) the widths of the lateral cuticular alae and cuticular expansions of the dorsal lip are good morphological criteria for separating *C. aduncum* and *C. clavatum*. In the former species they are very narrow whereas they are wide in the latter. Kreis (1952) has also drawn attention to the wide lateral cuticular alae as a good specific character of *C. clavatum*. The specimens from the prawn possess the narrow lateral cuticular alae as described for *C. aduncum*, but exhibit the wide angular cuticular expansions of the lips, as attributed to *C. clavatum*.

Kreis (1952) has stated that interlabia are absent in *C. clavatum*. If this is true then our specimens would be more closely allied to, if not identical with, *C. aduncum*. Dollfus (1952, p. 414), however, clearly illustrated interlabia in what he considered as *C. clavatum*.

Shulman and Shulman-Albova (1953) studied a large number of *Contracaecum* specimens from fishes of the White Sea and supported Punt in his view

that *C. clavatum* is a synonym of *C. aduncum*. However, it is apparent that they had not seen the publications of Kreis (1952) or Dollfus (1952).

Since, in our specimens, the cuticular alae are very narrow, even just behind the lips, we are tentatively indentifying our specimens with *C. aduncum*.

We have found nematodes, which are identical with those from the prawn, in the stomach of several fishes from the coastal waters of British Columbia. From three species of B. C. coast fishes, Smedley (1934) described a new nematode species, *Contracaecum magnum*, with which our specimens are probably identical. This species appears to be a synonym of *C. aduncum*. Olsen (1952) recorded the latter species from a rockfish (*Sebastodes caurinus* Richardson) caught near San Juan Islands, Washington State.

Nematodes of the genus *Contracaecum* (order ASCARIDATA: family ANISAKIDAE), as adults, are typically parasites of the digestive tract of fish-eating birds, mammals and fishes. Larval stages are known to occur encysted in the viscera of fishes and some have been found in invertebrates by Lebour (1917), Wülker (1930), Kahl (1936), Markowski (1937), Shulman and Schulmanova-Albova (1953).

To our knowledge adult *Contracaecum* have never been reported from an invertebrate host. It can be stated safely that the prawn is an abnormal definitive host for the *Contracaecum* sp. (? *C. aduncum*) here described, since only one of many thousands of prawns observed was infected. The nematode apparently is a normal parasite of the digestive tract of fishes.

SUMMARY

A heavy infection of a prawn, *Pandalus borealis*, by a nematode, *Contracaecum* sp., is recorded. A description, with illustrations, of the nematode is presented. The specific identity of the parasite is discussed. It is most closely related to, if not identical with, *Contracaecum aduncum* (Rudolphi, 1802). This is the only record of an invertebrate parasitized by adult *Contracaecum*.

REFERENCES CITED

DOLLFUS, R. PH. 1952 Parasites animaux de la morue Atlanto-Arctique, *Gadus callarias* L. (= *morhua* L.). Encyclopédie Biologique **43**: 423 pp.

KAHL, W. 1936 Beitrag zur Kenntnis des Nematoden *Contracaecum clavatum* Rud. Ztschr Parasitenk. **8**: 509–520.

KREIS, H. A. 1952 Beiträge zur Kenntnis parasitischer Nematoden. X. Parasitische Nematodes aus der Umgebung der Färoër. Vidensk. Meddl. fra Dansk. naturhist. Foren. **114**: 251–307.

LEBOUR, MARIE V. 1917 Some parasites of *Sagitta bipunctata*. J. Marine Biol. Ass. United Kingdom **11**: 201–206.

MARKOWSKI, S. 1933 Die Eingeweidewürmer der Fische des Polnischen Balticums (Trematoda, Cestoda, Nematoda, Acanthocephala). Arch. Hydrobiol. i Rybact. **7**: 1–58.

———1937 Über die Entwicklungsgeschichte und Biologie des Nematoden *Contracaecum aduncum* (Rudolphi, 1802). Bull. Internat. Acad. Polon. Sc. et des Lett., Cl. Sc. Math. et Nat., Ser. B: Sc. Nat. **2**: 227–247.

OLSEN, L. S. 1952 Some nematodes parasitic in marine fishes. Pub. Inst. Marine Sc. **2**: 172–215.

PUNT, A. 1941 Recherches sur quelques nématodes parasites de poissons de la Mer du Nord. Mém. (98) Mus. Roy. Hist. Nat. Belgique, 110 pp.

SHULMAN, S. S. AND SHULMAN-ALBOVA, R. E. 1953 Parasites of fishes of the White Sea. Acad. Sciences U.S.S.R. Moscow. 198 pp. (in Russian).

SMEDLEY, ENID M. 1934 Some parasitic nematodes from Canadian fishes. J. Helminth. **12**: 205–220.

WÜLKER, G. 1930 Über Nematoden aus Nordseetieren. II. Zoolog. Anz. **88**: 1–16.

Explanation of Plates

All drawings made with the aid of a camera lucida.

Plate I

Contracaecum sp. from *Pandalus borealis.*

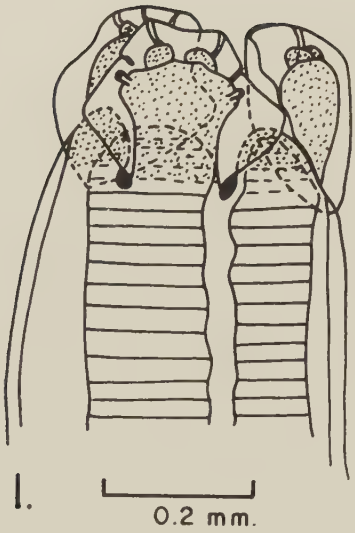
Fig. 1. anterior end, slightly off dorsal view.
Fig. 2. anterior end, dorso-ventral view.
Fig. 3. dorsal lip.
Fig. 4. ventro-lateral lip.
Fig. 5. head, en face view.
Fig. 6. cross-section through esophageal region, showing narrow lateral cuticular alae.

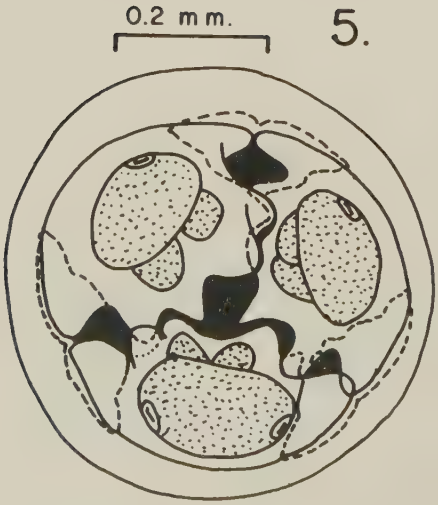
Plate II

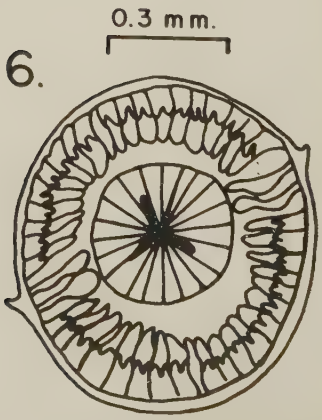
Contracaecum sp. from *Pandalus borealis.*

Fig. 7. ♂, posterior end, lateral view.
Fig. 8. ♂, tail, lateral view, showing distribution of post-cloacal papillae.
Fig. 9. region of ventriculus.
Fig. 10. ♀, vulvar region.
Fig. 11. ♀, posterior end.

PLATE I







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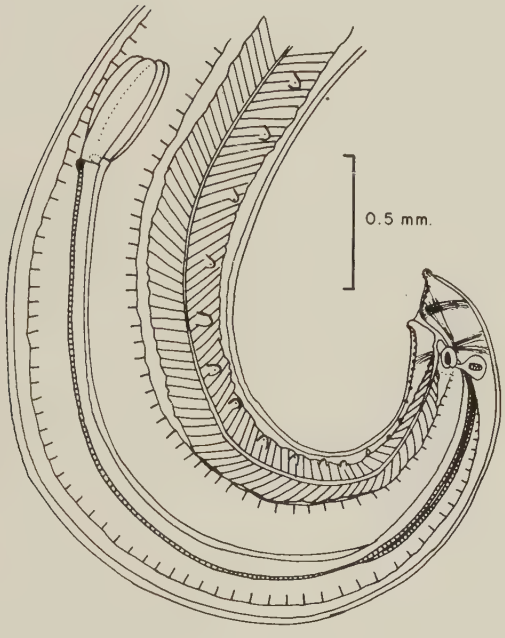

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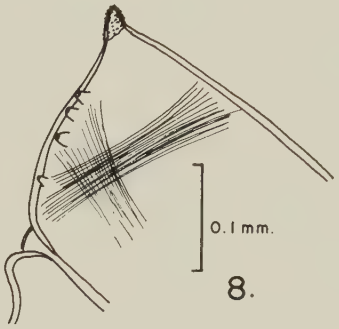

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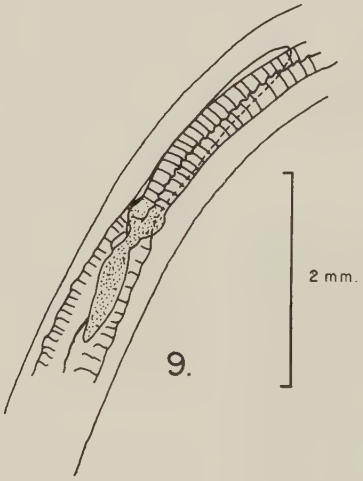

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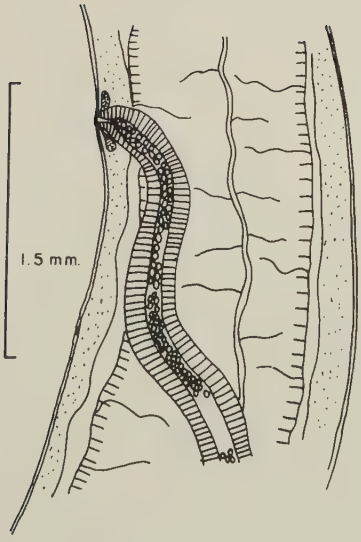

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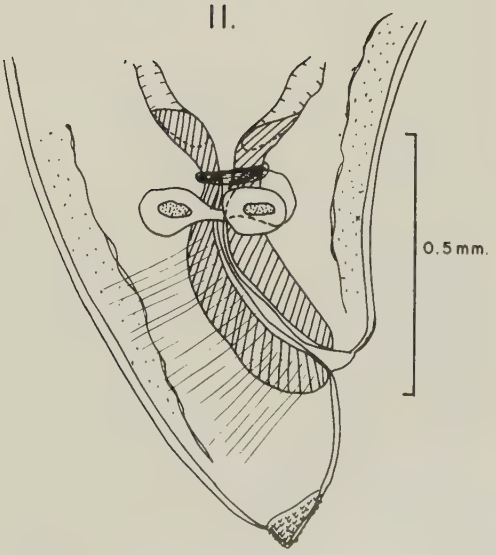

A NEW SPECIES OF TRYPANOSOME FROM THE SALAMANDER *AMBYSTOMA GRACILE*, WITH NOTES ON A COLLECTION OF AMPHIBIAN BLOOD SMEARS

Donald L. Lehmann
Department of Zoology, Oregon State College

During a period of 5 years, from 1949 through 1954, a total of 1192 west coast Amphibia, representing 10 genera and 16 species, have been examined for trypanosomes. Two species of haemoflagellates have been found, *Trypanosoma barbari* Lehmann, 1952 from *Taricha torosa* and a new species of trypanosome from larval *Ambystoma gracile,* which will be described below.

The first described species of urodelean trypanosome was *T. diemyctyli* Tobey (1906) from *Diemictylus viridescens* in the eastern United States; 7 years later Ogawa (1913) named *T. tritonis* from a Japanese newt, *Triturus pyrrhogaster.* Roudabush and Coatney (1937) found *T. cryptobranchi* in the blood of a North American *Cryptobranchus alleghaniensis* and the writer (1952) described *T. barbari* from a California salamander, *Taricha torosa.*

MATERIALS AND METHODS

The original investigation was begun at the Pacific Marine Station, Dillon Beach, California, and most of the remainder was completed in the laboratory of Dr. Ivan Pratt, Oregon State College.

Amphibia were collected in Oregon and California. All collections in Oregon were restricted to the Willamette Valley, while in California the majority of animals were captured in the counties surrounding San Francisco Bay; some specimens were taken as far north as Del Norte County and as far south as Los Angeles County.

Blood was taken from the tail of larger urodeles and from the heart of smaller Urodela and Salientia. Both blood-saline suspensions and smears stained with Wright's, Giemsa's or Heidenhain's haematoxylin were studied. Recently, thick smears, stained with Giemsa, have been used with success in finding light infections; the nuclei of normal blood elements do not interfere appreciably with the detection of parasites.

The writer has been fortunate in obtaining specimens of 3 of the 4 previously described species of urodelean trypanosomes for study and comparison with the new species: a slide of *T. tritonis* was loaned by Dr. A. S. Pearse, Duke University; *T. diemyctyli* were found parasitizing *Diemictylus viridescens,* obtained from the Chicago Biological Supply House, Inc.; and slides of *T. barbari* are in the writer's possession. The author is indebted to Mr. Nathan Cohen, Oregon State College, who gave him many specimens, including the larval *Ambystoma gracile.*

The number of animals examined, their places of origin and infections noted are shown in Table 1. The trypanosomes found were *T. ambystomae* n. sp. and *T. barbari* Lehmann, 1952.

Trypanosoma ambystomae n. sp.

The description is based upon the characters of 30 individuals taken from 4

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infected animals. The preparations studied were Wright-stained, thin smears. All measurements are in micra.

Trypanosoma ambystomae is a polymorphic trypanosome, with slender (Figs. 6–7), medium (Figs. 1–3) and broad individuals (Figs. 4–5) occurring in the same host; the medium forms predominate. Aside from differences in width, the parasites vary little with regard to the location of structures and staining characters.

T. ambystomae measures 36.4 long (28.8–43.7), 3.7 wide (1.8–7.7) and the free flagellum 17 (14–19.8). The red colored kinetoplast is perpendicular to the long axis of the body, rod-shaped, measuring on an average 0.8 by 0.3; it is 5.3 from the posterior extremity (3.4–7.7). The anteriorly placed nucleus is round to oval, has an indistinct nuclear membrane and the internal structure is homogenous and violet in color; no endosome could be demonstrated with Wright's stain. The nucleus measures 3.3 long by 3.8 wide (2.8–4.4 long by 2.5–7.7 wide). The

TABLE 1.—*West Coast Amphibians Examined for Trypanosomes*

Species	Number examined	Locality	Infection
URODELA			
Ambystoma californiense	1	Northern California	—
A. gracile	1	Northern California	—
A. gracile	12	Oregon	*T. ambystomae* (7 hosts)
Aneides ferreus	51	Oregon	—
A. flavipunctatus	28	Central California	—
A. lugubris	97	Central California	—
Batrachoseps a. attenuatus	184	Central California	—
B. attenuatus major	6	Southern California	—
Dicamptodon ensatus	3	Oregon	—
Ensatina e. eschscholtzi	135	Central California	—
E. eschscholtzi oreganus	20	Oregon	—
E. eschscholtzi picta	1	Northern California	—
Plethodon dunni	19	Oregon	—
P. vehiculum	26	Oregon	—
Taricha granulosa	71	Central California	—
T. granulosa	62	Oregon	—
T. torosa	189	Central California	*T. barbari* (91 hosts)
SALIENTIA			
Bufo boreas	9	Central California	—
Hyla regilla	136	Central California	—
H. regilla	27	Oregon	—
Rana aurora draytoni	98	Central California	—
R. aurora aurora	11	Oregon	—
R. boyli	7	Central California	—

distance from the anterior end of the body to the anterior border of the nucleus is 14.1 (11–16.6), and from the posterior end of the body to the posterior nuclear border the distance is 18.9 (14.8–24.2). Both body extremities are pointed and in most the cytoplasm is colored a mottled blue to purple with few granules and occasional vacuoles; in a few narrow and medium individuals the cytoplasm was filled with granules of varying size. The far anterior portion of the body is usually unstained, while the posterior portion from about the level of the kinetoplast has a mottled appearance being composed of large areas of unstained cytoplasm with islands of blue colored material. The undulating membrane is narrow in slender forms and broad and folded in the medium and broad individuals; the portion next to the body is usually granular, and the entire structure stains a light violet, while the bordering axoneme is pink. Myonemes may be seen in most of the medium and broad individuals and upon occasion in the slender forms. Dividing forms were not seen in stained preparations.

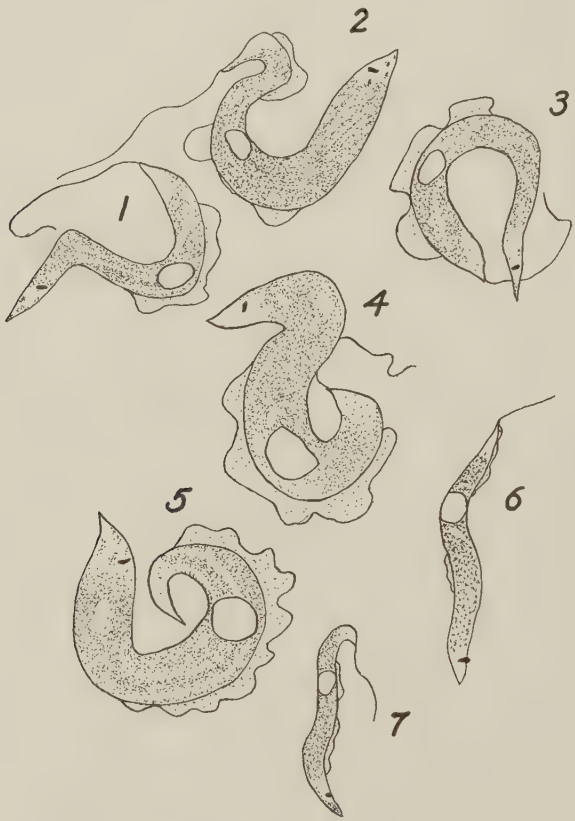
Host: larval *Ambystoma gracile.*

Habitat: blood.

Locality: Linn County, Oregon.
Types: U. S. N. M. Helm. Coll., No. 49,471; other slides in author's collection.

Trypanosoma barbari Lehmann, 1952

A study of *Taricha torosa* revealed that only individuals from Roland's Pond, Dillon Beach, California, were infected with this flagellate. Specimens of newts from other areas in Marin County, as well as Sonoma, San Mateo, Santa Cruz, Contra Costa and Alameda Counties, were never found infected with *T. barbari.*



EXPLANATION OF FIGURES

All figures were drawn with the aid of a camera lucida.
FIGS. 1–3. Medium forms of *Trypanosoma ambystomae.* (×940)
FIGS. 4–5. Broad forms of *T. ambystomae.* (×940)
FIGS. 6–7. Narrow forms of *T. ambystomae.* (×940)

COMPARISONS

T. ambystomae may be separated from both *T. diemyctyli* and *T. cryptobranchi* by the position of the nucleus which in *T. ambystomae* is definitely anterior in position while in the other two species the nucleus lies approximately at the center of the body. *T. ambystomae* as well as *T. tritonis* and *T. barbari* have anteriorly placed nuclei, but, in *T. barbari* measurements have shown that the center of the structure is, on the average, some 37% of the body length from the anterior end. The nuclei of *T. tritonis* and *T. ambystomae,* in relation to the above, average 42–43% of the body length from the anterior end.

The kinetoplast of *T. ambystomae* is rod-shaped and thereby differs from this structure in *T. barbari, T. diemyctyli* and *T. tritonis,* all of which fall within a spherical to oval grouping (although differing in other respects from one another). The kinetoplast in *T. cryptobranchi* was described by Roudabush and Coatney 1937) as being elliptical and usually lying perpendicular to the long axis of the body, and figured by them as an elongated ellipse; the rod-shaped kinetoplast in *T. ambystomae* is clearly different from this organelle in *T. cryptobranchi.*

Myonemes may have some significance in the classification of this group of trypanosomes: they are lacking in *T. cryptobranchi* and *T. barbari* and are present in *T. ambystomae, T. diemyctyli* and *T. tritonis;* the report of Ogawa (1913) does not describe myonemes, but these have been found by me in some large, broad individuals of *T. tritonis.*

SUMMARY

A total of 1192 amphibians from California and Oregon have been examined for trypanosomes. Two species have been found: *Trypanosoma barbari* Lehmann from *Taricha torosa* and a new species, *T. ambystomae,* from *Ambystoma gracile. T. ambystomae,* a polymorphic species, may be characterized by the anteriorly placed nucleus, rod-shaped kinetoplast and presence of myonemes.

LITERATURE CITED

LEHMANN, D. L. 1952 A new species of trypanosome from the Pacific coast newt, *Triturus torosus* (Rathke). Tr. Am. Micr. Soc., **71**: 135–138.

OGAWA, M. 1913 Sur un trypanosome de *Triton pyrrhogaster.* Compt. Rend. Soc. Biol., Paris, **75**: 268–271.

ROUDABUSH, R. L. AND COATNEY, G. R. 1937 On some blood protozoa of reptiles and amphibians. Tr. Am. Micr. Soc., **56**: 291–297.

TOBEY, E. N. 1906 Trypanosomiasis of the newt. J. Med. Research, **10**: 147–148.

STUDIES ON THE HELMINTH FAUNA OF ALASKA. XXIV. *ECHINOCOCCUS SIBIRICENSIS* N. SP., FROM ST. LAWRENCE ISLAND

ROBERT RAUSCH AND EVERETT L. SCHILLER*

As the result of field and laboratory investigations extending over a period of more than four years, we have amassed considerable information on the life cycle and ecology of a cestode of the genus *Echinococcus* (Rudolphi, 1801). Occurring on St. Lawrence Island, which lies in Bering Sea about 40 miles southeast of Cape Chukotskyi, Northeast Siberia, this cestode not only has an interesting life cycle, but in the larval stage is an important parasite of man.

Two outstanding characteristics serve to differentiate this cestode from the known species of *Echinococcus:* 1) the natural occurrence of the larval stage in microtine rodents; 2) an alveolar-form larva which is produced through exogenous budding. Although this cestode cannot always be differentiated from *E. granulosus* (Batsch, 1786) on the basis of morphological characters in the adult stage, it is nevertheless specifically distinct and is described herein as new.

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* Animal-borne Disease Branch, Arctic Health Research Center, Public Health Service, U. S. Department of Health, Education, and Welfare, Anchorage, Alaska.

Echinococcus sibiricensis n. sp.

(Figs. 1–2)

Diagnosis: Strobila very small, from 1.2 to 3.7 mm. long; 2 segments usually present, sometimes 3 or 4 in old specimens. Testes number 17 to 26 (av. 22); distributed in posterior half of segment. Cirrus sac averages 90 by 50 microns. Rostellar hooks, 26 to 36 in number (av. 30). Large hooks measuring 23 to 29 microns (av. 27); small hooks 19 to 26 microns (av. 21.6). Eggs measuring 30 to 38 microns (av. 34) by 29 to 34 microns (av. 30). Sacculations of gravid uterus not evident.

Final (type) host: Arctic fox, *Alopex lagopus* L. Occurs also in sledge dogs.

Intermediate hosts: Field vole, *Microtus oeconomus innuitus* Merriam, and red-backed vole, *Clethrionomys rutilus albiventer* Hall and Gilmore. (Other microtine rodents experimentally infected.) Also in man.

Habitat: Adult in the small intestine of fox and dog. The liver is the primary locus of infection in the intermediate host.

Type locality: St. Lawrence Island, Alaska. Occurs also on Bering Island, Komandorskii Islands.

Types: Deposited in the Helminth. Coll. U. S. Nat. Museum, No. 49442 slide with type and paratypes, and Nos. 49443 and 49444 paratypes *in situ* in two field voles.

DISCUSSION

Rausch (1953a)[1] concluded that four species of *Echinococcus* are valid; viz., *E. granulosus* (Batsch, 1786), *E. oligarthrus* (Diesing, 1863), *E. lycaontis* Ortlepp, 1934, and *E. felidis* Ortlepp, 1937. *E. sibiricensis* n. sp. is readily differentiated from all but *E. granulosus* on the basis of morphological characteristics in the adult stage. When compared with *E. granulosus, E. sibiricensis* n. sp. has fewer testes having a more restricted distribution, and the hooks are smaller in average size. However, when compared with adult cestodes from the Arctic Coast of Alaska and from Nunivak Island (occurring in both *Alopex lagopus* L. and *Vulpes vulpes* L.), the St. Lawrence Island form cannot always be differentiated. Morphological variation in *E. granulosus* has been considered in detail by Rausch (1953a).

The St. Lawrence Island cestode is, however, readily differentiated from *E. granulosus* on the basis of larval form and host-species parasitized by the larval stage. While *E. sibiricensis* n. sp. occurs naturally, as far as we have determined, only in the field vole and red-backed vole on St. Lawrence Island, we have succeeded in infecting experimentally microtine rodents of other species; viz., *Microtus pennsylvanicus* Ord, *M. californicus* Peale, *Lemmus sibiricus trimucronatus* Merriam, and *Ondatra zibethica* L. A single specimen of *Peromyscus* sp. was infected, but rodents of this genus appear to be relatively refractory. We have not attempted infection of the varying lemming, *Dicrostonyx torquatus* Pallas, but further observations are needed in this case, since this lemming also occurs on St. Lawrence Island (see Rausch, 1953b). We have been completely unsuccessful in establishing experimental infections in any of these animals through the administration of the eggs of *E. granulosus*. The experimental work will be discussed in detail in another publication.

E. sibiricensis n. sp. differs markedly from *E. granulosus* in larval form and in mode of larval growth. Detailed comparisons with the larval stage of *E. granulosus* have been made, and consistent differences exist. Detailed observations on larval development and morphology have been reported in another publication (Rausch, 1954).

[1] In this paper the dorsal longitudinal excretory canals were unintentionally portrayed as having transverse connections in the St. Lawrence Island species (page 243, text fig. 2).

The larval form of the St. Lawrence Island cestode closely resembles the alveolar larva of *Echinococcus* sp. which sometimes occurs in man in southern Europe and Russia, although there is no knowledge of any involvement of microtine rodents in the life cycle of the latter. There has been no adequate study of the Eurasian cestode, and no one has ever succeeded in obtaining the alveolar larva experimentally. Nevertheless, in the opinion of the writers, it is probable that the two forms are identical.

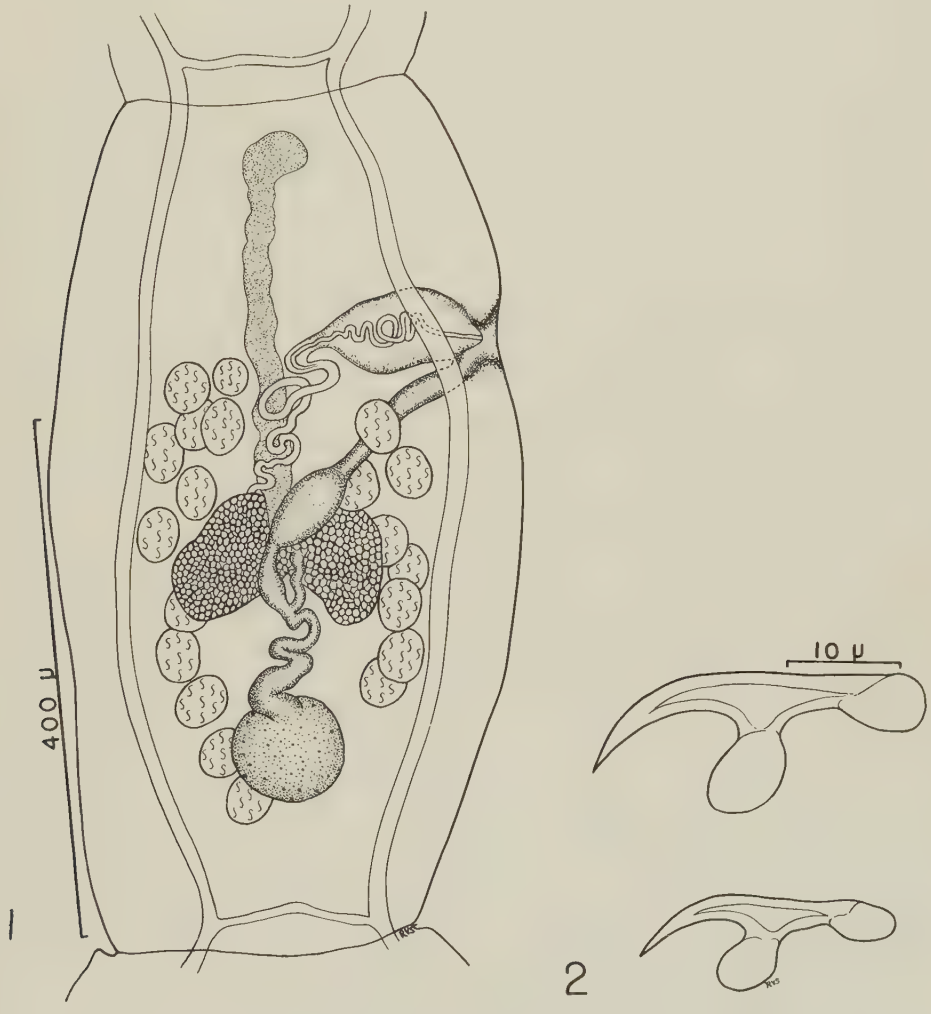

FIG. 1. *Echinonoccus sibiricensis* n. sp. Mature segment, ventral view.
FIG. 2. *Echinococcus sibiricensis* n. sp. Rostellar hooks.

All available evidence indicates that the species described here from St. Lawrence Island (and existing also on Bering Island) is of Siberian origin. It apparently has been brought to St. Lawrence Island by arctic foxes coming in on the pack ice from Siberia (Rausch, 1953b). It was probably established on Bering Island through the introduction of red-backed voles, either accidentally or for the purpose of providing food for foxes. Stejneger (1884, p. 88) stated that red-

backed voles were not present on Bering Island prior to 1870. Barabash-Nikiforov (1943) stated that reports exist on the voles having been deliberately introduced in order to increase the food resources of the arctic fox, and Johansen (1950, p. 47) also believed that deliberate introductions had taken place. The origin of such voles is apparently unknown, but it is perhaps safe to assume that it was the adjacent Siberian mainland. Since the pack ice does not reach Bering Island, the foxes have not come naturally to Bering Island in recent time. As pointed out by Afanas'ev (1941, p. 100), foxes on Mednyi Island are not infected, because no voles are found there. Unfortunately, there is little information on the occurrence of the alveolar larva of *Echinococcus* in Siberia. Pavlovskii (1946, p. 337) stated that human cases are diagnosed annually in Irkutsk, but gave no additional information. Spasskii, Romanova, and Naidenova (1951, p. 49) reported the larvae of *"E. granulosus"* in the liver, spleen, and testicle of muskrats farther to the west in the Kurganskaya Oblast' and Kzyl-Orda. It is unlikely that the species involved here is *E. granulosus,* and it may be *E. sibiricensis* n. sp.

It is possible that *E. sibiricensis* n. sp. may eventually be found identical with the species causing alveolar hydatid disease in man in Eurasia. If such were true, it would be difficult to determine whether any previously existing name can be applied, in view of the considerable amount of confusion concerning the nomenclature of the South-European and Russian species of *Echinococcus.*

We hope that this problem may be resolved through appropriate experimental study of the Eurasian cestodes, since only then can the affinities of *E. sibiricensis* n. sp. be ascertained.

Literature Cited

Afanas'ev, V. P. 1941 Parazitofauna promyslovykh mlekopitaiushchikh Komandorskikh Ostrovov. Uchenie Zapiski, Seriia biologicheskikh Nauk. **18:** 93–117.

Barabash-Nikiforov, I. 1943 (On the mouse-like rodents (family Muridae) of the Commander Islands.) (In Russian.) Zool. Zhur. **22:** 53–54.

Johansen, H. 1950 Polarraeven på Kommandørøerne. Naturens Verden. **34:** 37–59.

Pavlovskii, E. N. 1946 Rukovodstvo po parazitologii cheloveka. Vol. 1. Moscow-Leningrad. 521 p.

Rausch, R. 1953a The taxonomic value and variability of certain structures in the cestode genus *Echinococcus* (Rud., 1801) and a review of recognized species. Thapar Commemoration Volume. Lucknow, India. p. 233–246.

————1953b On the land mammals of St. Lawrence Island, Alaska. Murrelet. **34:** 18–26.

————1954 Studies on the helminth fauna of Alaska. XX. The histogenesis of the alveolar larva of *Echinoccocus* sp. J. Infect. Dis. **94:** 178–186.

Spasskii, A. A., Romanova, N. P., and Naidenova, N. V. 1951 Novye dannye o faune paraziticheskikh chervei ondatry—*Ondatra zibethica* (L.). Akad. Nauk SSSR **5:** 42–52.

Stejneger, L. 1884 Contributions to the history of the Commander Islands. No. 1. Notes on the natural history, including descriptions of new cetaceans. Proc. U. S. Nat. Mus. **6:** 58–89.

ESTIMATING RELATIVE POLLUTION OF THE ENVIRONMENT WITH OOCYSTS OF *EIMERIA STIEDAE*

EVERETT E. LUND
Animal Disease and Parasite Research Branch
Agricultural Research Service
United States Department of Agriculture

In studying the epidemiology of a parasitic disease, it is often very helpful to have some means of determining the extent to which the soil or the surroundings are polluted with the infective stages of the causative organism, and how great is the hazard of their being acquired. It is also important to know approximately how many organisms are involved in naturally acquired infections, so experimental work can be carried on within this range. Otherwise, the results of controlled experiments may be difficult to translate into principles of practice, thus causing some loss of their possible value.

From the standpoint of economic loss to the grower, hepatic coccidiosis is the most important parasitic disease of domestic rabbits. Mortality is usually quite low, or comes as the result of secondary infections or complications that tend to draw attention away from the initial disorder. The greatest losses come because the disfigured livers, or the entire carcasses containing such livers, must be discarded. The grower is usually not aware of the significance of the infection for some time after it has been acquired. In order to assist him in controlling the trouble, it is desirable to know when his animals acquired the infection, and the prevalence of the causative organism on the premises.

Within the limits likely to be encountered, liver coccidiosis runs a rather orderly course, with orderly variations according to the age of the infection, the size of the infective dose or doses, and the distribution of the times of infection, if there are several and they are all within a few days of each other. Active multiplication of the parasite takes place only in the liver, and this is the organ that varies with the progress and intensity of the infection.

Smetana (1933) determined the course of the disease in the liver by studying the progression of intracellular stages from the 6th to the 18th days of infection, and by studying the healing stages that followed.

Jankiewicz (1945a) demonstrated that on the 22nd day after infection there was a relationship between the weight of the livers of rabbits with hepatic coccidiosis and the size of the infective dose that had been administered.

Several workers have determined the relative weight of the liver of the healthy rabbit at different ages. Levine, Mann, Hodge, Ariel, and DuPont (1941) found that it constituted about 3.6 percent of the total body weight of animals of about 6 pounds. Jankiewicz (1945b) found it to be 3.7 percent of the total weight of animals of 4.5–5.0 pounds. Lund (unpublished data) determined from a study of several hundred freshly slaughtered animals of 3.5–4.5 pounds that the liver constituted 3.75 percent of the weight of the body, on the average.

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METHOD

Forty-four New Zealand white rabbits of 8-9 weeks of age, and weighing between 3.6 and 4.7 pounds were each given 5,500 sporulated oocysts of *Eimeria stiedae,* these being introduced directly into the stomach through a soft rubber catheter. Animals were killed on the 16th, 22nd, 28th, 34th, and 40th days after being infected, and the progress of the disease was studied in each case. Weights of animals at slaughter, and of their pelts, viscera, dressed carcasses and livers were recorded.

Using the same suspension of oocysts, 8 animals of similar ages and weights were given 10,000 oocysts each, and 4 were killed on the 21st day and 4 on the 27th day after infection, and studied as above.

Concurrently with the above, animals free of *E. stiedae* were turned into large grass plots of 0.3 and 0.6 acres, containing rabbits known to have liver coccidiosis, or having had such animals but having been vacated for several months. The animals were then caught at intervals ranging from 8 to 36 days, and were killed and studied to determine the progress and intensity of the disease. It was hoped that this system would afford a means of determining the relative pollution of the ground with viable oocysts. Animals were also placed in hutches that were occupied by infected rabbits, and these too were killed at times when evidence of infection should have been obvious, if it had taken place.

RESULTS AND INTERPRETATION

As Jankiewicz had pointed out, the most easily measured change related to the size of the infective dose was the weight of the liver relative to that of the entire body. The relative weight of the liver varied with the age of the infection also, but there was little change between the 22nd and 34th days, as Figure 1 shows. It was usually not difficult to distinguish cases that fell within this range from those that were appreciably removed from it. During this time the lesions on the liver were most clearly defined, and the preponderance of oocysts in the gall bladder were normal in appearance. In extremely heavy infections a high proportion of abnormal oocysts sometimes began to appear early, but the clear delineation of the spots, and the great distention of the gall bladder and bile ducts indicated that the infection had not subsided.

Over a period of 2 years several hundred rabbits were raised in a warren consisting of 0.6 acre of grass land. Most of the young rabbits were 8 to 12 weeks of age when they were caught, and 340 of them showed *E. stiedae* infections that indicated that the hypertrophy of the liver should be near its maximum. Only 3 rabbits of similar age were entirely free of infection. The manner in which 343 animals were distibuted with respect to the size of a single dose of oocysts required to produce comparable symptoms is shown in Fig. 2. The average case was like that produced by 1000 oocysts, and 10 percent of the animals had cases equivalent to those produced by the ingestion of less than 100 oocysts in a single dose. Only 6 percent had cases more severe than those produced by 10,000 oocysts. However, 7.7 percent of the young rabbits had died with liver coccidiosis and ensuing complications, and most of these were heavily infected.

After the grass plot had been in use for 5 months, 11 hutch-raised rabbits of 8 weeks of age were turned into the warren for 21 days. At slaughter liver weights

ranged from 3.4 to 4.6 percent of their body weights, and averaged 4.1 percent. This indicates that the average infection was lighter than that produced by a single dose of 100 oocysts. Even the most severe infection more closely resembled one produced by 100 oocysts than one produced by 1000 oocysts. The rabbits apparently ingested only about 1/10 as many oocysts that proved capable of infection as were ingested by the rabbits reared since birth in the same warren. There are at least 3 reasons why the animals reared in the warren were more heavily infected. One reason is that these animals became infected about 3 weeks earlier than those introduced after having reached 8 weeks of age. At the age of 5 weeks the rabbits usually stayed near their burrows, which were commonly where there was a good turf to hold the soil. This turf afforded good grazing, but at the same time it provided excellent protection for oocysts.

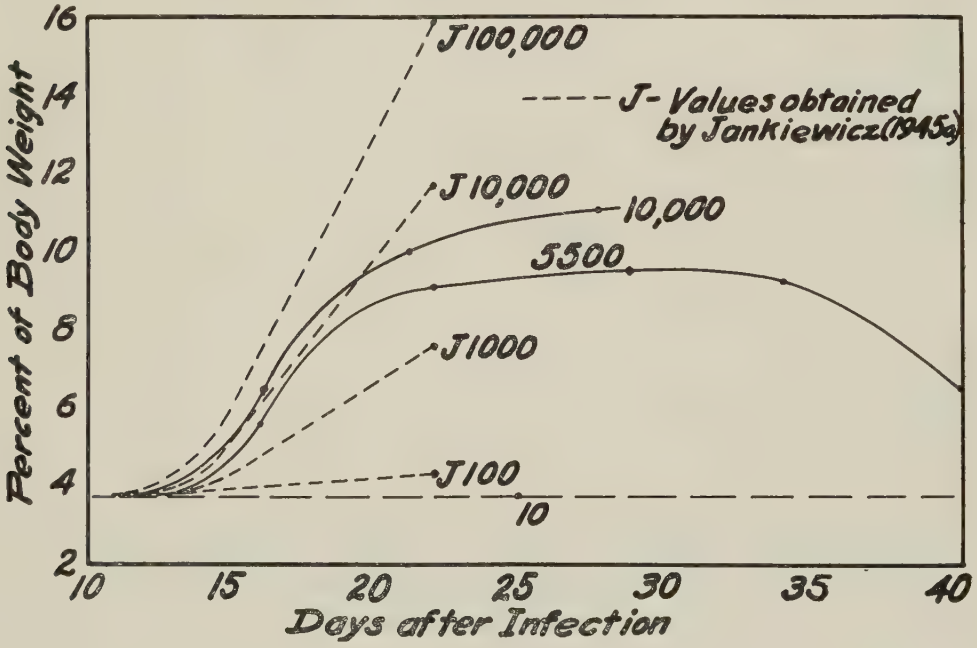

FIG. 1. Relation of the hypertrophy of the liver to the number of oocysts of *E. stiedae* administered in one dose.

A second reason is that animals accustomed to forage spent much more time grazing than did the hutch-raised rabbits. The latter sought out the self-feeders with the pelleted ration they were accustomed to having, and grazed largely for the novelty it afforded.

Finally, the continued ingestion of oocysts undoubtedly has a tendency to intensify cases somewhat, but not in proportion to the cumulative total. Continued feeding of oocysts tends to prolong cases somewhat.

Thirty-two rabbits were released in warrens that had once been occupied by rabbits heavily parasitized by both intestinal and hepatic coccidia. Many of the animals were captured and killed before macroscopic evidence of *E. stiedae* infection could have appeared. However, 13 remained long enough so such evidence could have been discernible. Of these, 2 were negative when caught, 1 had become in-

fected on the third day in the warren, 3 on the fourth, 3 on the fifth, and 1 on each day following, through the tenth day, as nearly as could be determined. As sometimes occurs, several of the animals had small livers. No liver was hypertrophied, and spotting in each indicated that the infection was with but a few oocysts. It had been determined experimentally that a single dose of 10 oocysts produced rather pronounced spotting, but no discernible increase in the relative weight of the liver. The heaviest infection observed among these 11 animals was no more pronounced than infections produced by 10 oocysts, and most cases were much lighter. If the infection of these animals introduced into warrens that were vacant 6 to 8 months indicated the ingestion of less than 1/10 the oocysts acquired in plots occupied continuously, and it took 5 times as long to encounter the oocysts, it appears that

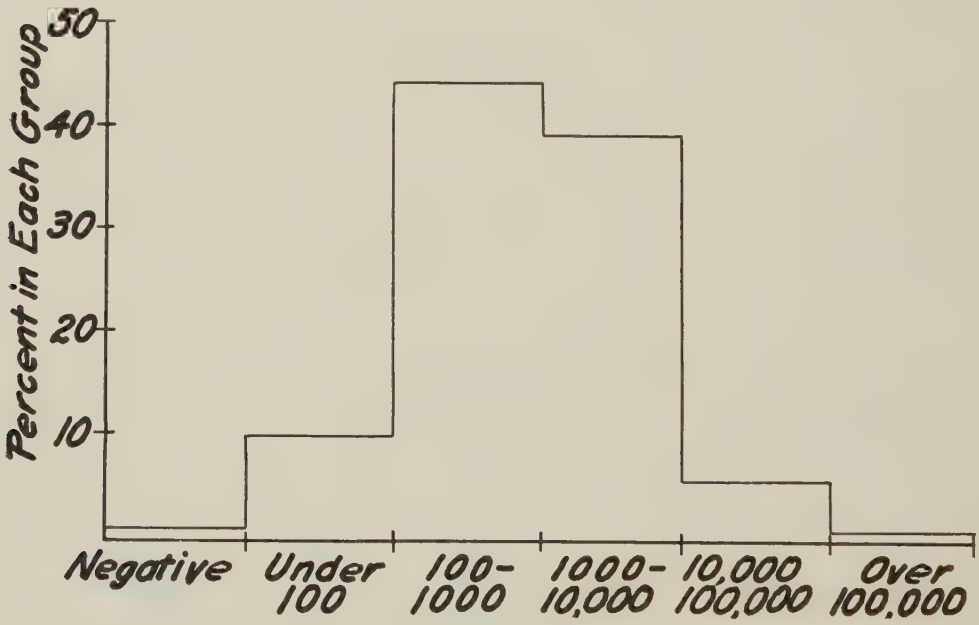

FIG. 2. Distribution of 343 young rabbits reared on the ground, classified on the basis of liver hypertrophy and presumed oocyst intake.

the ground pollution averaged less than 2 percent of that of the plot occupied continuously.

When 19 young rabbits were placed in 3 hutches with floors of metal fabric, and allowed to remain 4 weeks with a rabbit with a light infection with *E. stiedae,* 9 acquired very light infections comparable to those produced by about 10 oocysts. In close confinement young rabbits wash each other, and this practice, and the use of a common drinking valve and self-feeder, provide minor opportunities for the spread of oocysts. Similar confinement of young rabbits with an infected one in a hutch that had half of the floor solid, but sloping 1″ to the foot (Lund, 1952), or in which a burlap bag covered a part of the floor, resulted in 100 percent infection in 4 weeks, and the infections resembled those caused by about 100 oocysts. The solid substratum appeared to be at least 20 times as effective in spreading the oocysts as the more incidental means operative when self-cleaning floors were used.

SUMMARY AND CONCLUSIONS

1. A single dose of only 10 oocysts of *E. stiedae* in rabbits 8 weeks of age produced no hypertrophy of the liver, but appreciably larger doses produced increases in the weight of the liver that varied directly and more or less proportionately to the increase in the size of the dose.

2. These increases were most constant after the 22nd day of infection, and before the 34th day.

3. Used as a means of estimating the relative degree of infection of rabbits acquiring the disease naturally, it was found that on grass plots heavily populated with rabbits, a small proportion of the young animals acquired infections equal to those caused by the simultantous ingestion of over 100,000 oocysts. The average infection resembled those produced by the ingestion of about 1000 oocysts, and a few rabbits escaped infection entirely, for 8 weeks.

4. Hutch-raised rabbits that ran about less when released in the warrens than those reared exclusively on the soil, and that grazed less, acquired infections of only 1/10 the average intensity of the rabbits permanently occupying the same warren.

5. Warrens that remained unoccupied for 6 to 8 months, including the dry summer months, were only 2 percent as infective as when occupied continuously.

6. Close confinement of young rabbits in hutches with self-cleaning floors of metal fabric permitted some spread of the disease, but the hazard increased by 20 times when half of the floor was covered with wood or a burlap bag.

LITERATURE CITED

JANKIEWICZ, H. A. 1945a Dosage of *Eimeria stiedae* related to severity of liver coccidiosis. J. Parasit. **31** (Suppl.): 8.

———1945b Liver coccidiosis prevented by sulfasuxidine. J. Parasit. **31** (Suppl.): 15.

LEVINE, C. J., MANN, W., HODGE, H. C., ARIEL, I., AND DUPONT, O. 1941 Distribution of body weight of organs and tissues of the rabbit. Proc. Soc. Exper. Biol. and Med. **47**: 318–321.

LUND, EVERETT, E. 1952 Relation of hutch floor construction to parasitism in domestic rabbits. Small Stock Mag. **36**: 3 and 42.

SMETANA, HANS 1933 Coccidiosis of the liver of rabbits. III. Experimental study of the histogenesis of coccidiosis of the liver. Arch. Path. **15**: 516–536.

THE APPARENT TRANSFER OF PYRIMETHAMINE-RESISTANCE FROM THE BI STRAIN OF *PLASMODIUM GALLINACEUM* TO THE M STRAIN

JOSEPH GREENBERG AND HELEN LOUISE TREMBLEY

U. S. Department of Health, Education, and Welfare
Public Health Service
National Institutes of Health, National Microbiological Institute
Laboratory of Tropical Diseases, Bethesda 14, Maryland

Chicks infected with sporozoites of the BI strain of *Plasmodium gallinaceum* (normally blood-passaged) die as a result of the growth of late tissue forms of the parasite before normal erythrocytic parasites develop (Haas, Wilcox, Laird, Ewing, and Coleman, 1948; Trembley, Greenberg, and Coatney, 1951; Greenberg, Coatney,

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and Trembley, 1954). Chicks infected with sporozoites of the M strain of this parasite (normally mosquito-passaged) do not usually die of the infection; late tissue forms are not detected in routine examination of brain smears made when the chicks are killed. This does not mean that the M strain is devoid of late tissue forms (Dr. Clay G. Huff has found such forms in serial sections of brain and other tissues); but such forms are too rare to contribute to the death of the chicks or to be observed by less searching techniques. The BI strain, then, is lethal, causing death by an abundance of easily observable, late tissue forms; the M strain is benign, late tissue forms being too rare to cause the death of the chick or to be observed by routine techniques. The BI strain cannot normally be transmitted more than one time by mosquitoes, because the host dies before normal, pigmented erythrocytic parasites are produced. However, if the chicks infected by sporozoites of the BI strain are treated with pyrimethamine to prevent death, the BI strain can be transmitted once more by mosquitoes without any change in the characteristics of the strain (Greenberg, Coatney, and Trembley, 1954).

When the M and BI strains were passed simultaneously through *Aedes aegypti* (Greenberg and Trembley, 1954), chicks inoculated with the resulting sporozoites died of causes attributable to abundant late tissue forms after the appearance of normal erythrocytic parasites. After a second passage through mosquitoes the infections were benign, late tissue forms, if present, being too rare to kill the chicks or to be detected in the routine examination of brain smears. Even when the infections resulting from the first mosquito passage of the two strains were treated with pyrimethamine, presumably favoring the subsequent transmission of the lethal, BI strain, the infections resulting from a second mosquito passage were benign (Trembley and Greenberg, 1954). The ability of the parasite to cause the death of the chicks by late tissue forms, present after the first potential hybridization of the strains, was lost upon subsequent passages through the mosquito. If hybridization between the two strains occurred, these results would be difficult to explain in terms of simple mendelian genetics. We have suggested (Trembley and Greenberg, 1954) that the M strain gametes carry a cytoplasmic factor, absent in the BI strain, which inhibits the multiplication of the parasite in the fixed tissues. Alternatively it is possible that no hybridization occurred; that the strains were carried in parallel, and that the BI strain disappeared by mechanical dilution because it produced relatively few gametocytes compared with the M strain.

In order to determine whether hybridization occurs between the strains, the M strain was passaged through mosquitoes simultaneously with a BI substrain made 64-fold resistant to pyrimethamine (Greenberg and Bond, 1954). This paper reports the apparent transfer of drug-resistance from the BI strain to the M strain through two consecutive mosquito passages without the intervention of therapy.

MATERIALS AND METHODS

New Hampshire red chicks three to seven days old were used. The vector was laboratory-reared *Aedes aegypti.* Two strains of *Plasmodium gallinaceum* (M and pyrimethamine-resistant BI) were used; their principal characteristics are described in the first paragraph of this paper. The methods of inoculating blood and of making and reading blood smears for parasitemia have been described by Coatney, Cooper, Eddy, and Greenberg (1953). One mosquito equivalent of sporo-

zoites was inoculated, and brain smears made and evaluated according to the method recommended by Coatney, Cooper, and Trembley (1945). Blood smears were examined daily or every other day beginning day 7 (day of inoculation is day 0). Brain smears were made of all chicks at autopsy and were examined for tissue forms of the parasite. Birds with negative results were examined until day 30, at which time they were killed. The infection was considered aborted if erythrocytic parasites were not detected prior to day 30. Chicks with proven infections were killed generally a week or more after they first exhibited parasites.

Pyrimethamine was administered orally by catheter in dilute lactic acid.

The term, F_1 generation or infection, referred to in this paper will mean the parasites derived from a first mosquito passage; F_2 and F_3 will mean the parasites derived from the second and third mosquito passages, respectively. This is done for convenience, and the symbols obviously do not refer to the direct offspring of controlled matings as they do in classical genetics.

RESULTS

M strain

The effect of single doses of pyrimethamine, administered on the day after inoculation, on "pure" M strain, sporozoite-induced infections is shown in Table 1. The F_1 data are the pooled results of two independent experiments. The infection was aborted in more than half the chicks when doses of 0.0005 mg./g of body weight or more were administered. None of the chicks treated with 0.004 mg./g or more had infections detectable within 30 days after inoculation. However, 4 of 10 chicks treated with 0.002 mg./g developed infections. One of these chicks, which became positive on day 15, was used as a donor to feed mosquitoes on day 17, at which time it had 3 percent of its red cells infected. Fourteen days later 74 of the mosquitoes (estimated 100 percent positive for sporozoites) were pooled and comminuted in serum-saline, and appropriate aliquots of the preparation were inoculated into 30 chicks. Five of these chicks served as untreated controls, the remainder, in groups of 5, were treated with graded, single doses of pyrimethamine on the day after inoculation (Table 1, F_2). The smallest dose tested (0.002 mg./g) was able to abort the infection in more than half the chicks. There was no evidence that drug resistance developed after the parasite was exposed to the drug once.

TABLE 1.—*The effect of single doses of pyrimethamine on the M strain of* Plasmodium gallinaceum

Dosage of pyrimethamine 1 dose, day 1 mg./g.	Number chicks infected/number inoculated	
	F_1	F_2
None	5/ 5	5/5
0.00025	4/ 5	
0.0005	4/10	
0.001	0/10	
0.002	4/10*	0/5
0.004	0/ 5	0/5
0.008	0/ 5	0/5
0.016	0/ 5	0/5
0.032		0/5

* One chick of this group used as donor for next passage (F_2).

M × pyrmethamine-resistant BI

Five chicks were inoculated with approximately equal numbers of trophozoites of

TABLE 2.—*The effect of single doses of pyrimethamine on mixed, M and pyrimethamine-resistant BI strains of* Plasmodium gallinaceum. *Line I*

Dosage of pyrimethamine 1 dose, day 1 mg./gm.	Number chicks infected/number inoculated				
	F_1	F_2†	F_3†		
			(a)	(b)	(c)
None	10/10*	10/10	5/5	5/5	5/5
0.0005		3/ 5			
0.001		4/ 5(a)			
0.002		3/ 5	5/5	5/5	
0.004		5/ 5	5/5	4/4	
0.008		3/ 5(b)(c)	5/5	5/5	
0.016		3/ 5	5/5	5/5	5/5
0.032			5/5	4/4	5/5

* All chicks died day 10 or 11 with late tissue forms of the parasite. Two chicks served as donors for next (F_2) mosquito passage.
† None of the infected chicks exhibited late tissue forms. (a), (b), and (c) indicate single chick from this group served as donor for next (F_3) mosquito passage.

the M and the BI strains (8×10^6). Five days later one of the chicks (with a parasitemia of 82 percent) was used to feed mosquitoes, initiating a line of passage which we shall call Line I. Another chick was used four days after the original inoculation of parasites to feed mosquitoes, initiating Line II; it had a parasitemia of 72 percent.

M × pyrimethamine-resistant BI Line I.—Thirteen days after mosquitoes had fed on the original donor of Line I, 20 mosquitoes (estimated 100 percent positive for sporozoites) were pooled and comminuted in serum-saline and appropriate aliquots of the preparation inoculated into 10 chicks. All of these chicks developed infections with normal erythrocytic parasites, and all died between the 10th and 12th day after inoculation of overwhelming fixed tissue infections (Table 2, F_1). Two of the F_1 chicks were used to feed mosquitoes; both had been parasite-positive for three days, and had parasitemias of 4.5 and 2.0 percent, respectively. Twelve to 13 days later 70 mosquitoes (estimated 90 percent positive for sporozoites), from both donors, were pooled and comminuted in serum-saline; 40 chicks were inoculated with appropriate aliquots of the preparation. Ten of the chicks were untreated and the remainder, in groups of 5, were treated on the day after inoculation with single graded doses of pyrimethamine as shown in Table 2, F_2. Doses as high as 0.016 mg./g failed to protect the chicks from the infection. One chick treated with pyrimethamine, 0.001 mg./g, positive on day 8, was used to feed mosquitoes on day 13 (percent of parasitemia undetermined). Ten days later 57 mosquitoes (estimated 100 percent positive for sporozoites) were pooled as usual and used to inoculate 30 chicks, treated as shown in Table 2, F_3 (a). Dosages of 0.032 mg./g did not abort the infection in any of the chicks. Similar results were obtained (Table 2, F_3 (b) (c)) when chicks of the F_2 series, treated with 0.008 mg./g, were used as donors.

TABLE 3.—*The effect of single doses of pyrimethamine on mixed, M and pyrimethamine-resistant BI, strains of* Plasmodium gallinaceum. *Line II*

Dosage of pyrimethamine 1 dose, day 1 mg./g.	Number chicks infected/number inoculated	
	F_1†	F_2†
None	10/10*	5/5
0.001		3/5
0.002		1/5
0.004		0/5

* Chick of this group used as donor for next (F_2) mosquito passage.
† None of the infected chicks exhibited late tissue forms.

None of the chicks in the F_2 or the F_3 series exhibited tissue forms when they were killed and autopsied on days 18–28.

M × pyrimethamine-resistant BI Line II.—Thirteen days after mosquitoes were fed on the donor of Line II, 15 mosquitoes (percent positive undetermined) were pooled and inoculated, as usual, into 10 chicks (Table 3, F_1). All of these chicks developed a normal parasitemia but none died of late tissue infections and no late tissue forms were discovered when they were autopsied on the 24th day after inoculation. Two of the chicks, positive on day 8, were used to feed mosquitoes on day 10, when they had parasitemias of 1.5 and 2.5 percent, respectively. Eighteen days later 20 mosquitoes (estimated 100 percent positive for sporozoites) were pooled and inoculated as usual into 20 chicks (Table 3, F_2). Five of these chicks were untreated and the remainder, in groups of 5, were treated the day after inoculation with graded, single doses of pyrimethamine as shown in Table 3, F_2. A dose of 0.002 mg./g was sufficient to abort the infection in over half the chicks.

DISCUSSION

As a result of, or coincident with, the simultaneous passage of the M strain and a pyrimethamine-resistant BI substrain through mosquitoes, a high degree of pyrimethamine-resistance was demonstrated in a strain behaving as the M strain. To all appearances, a benign strain was produced, without prior exposure to the drug, which was 64-fold more resistant to pyrimethamine than the parent M strain yet almost equal in resistance to that acquired by the BI strain at the time the 2 strains were exposed to "hybridization." This phenomenon did not occur when the presence of the BI strain (presence of detectable numbers of late tissue forms) could not be demonstrated after the first mosquito transfer from a chick inoculated with both strains (Table 3, F_1). When, however, the presence of tissue forms and, therefore, presumably the BI strain, was demonstrable in the F_1 infections, drug resistance was demonstrable in the F_2 infections, though the ability of the parasite to proliferate in the fixed tissue had disappeared. Furthermore, no evidence has been obtained for the spontaneous development, in pure M strain passages, of any significant degree of pyrimethamine-resistance. Nor was there any evidence of the development of drug resistance even after the parasite had been exposed to the drug once.

There are many possible explanations for the results obtained. Perhaps the simplest is that pyrimethamine-resistance is inherited through one gene or a few genes, whereas proliferation in the fixed tissues is controlled by a cytoplasmic factor, by many genes, or by a combination of these influences. The relative scarcity of pyrimethamine-resistant parasites in the F_2, as indicated by the erratic results in the treated chicks, could be a reflection of the small number of hybrids in the F_1, the BI strain being a poor gamete-producer. Alternatively or additionally, it could mean that hybrids between pyrimethamine-sensitive and pyrimethamine-resistant parasites were intermediate in their resistance to the drug. Or it could signify that resistance is inherited through more than one recessive gene. More consistent results were obtained in treated chicks of the F_3 passages, after selection for drug resistance had occurred.

Another possible explanation of the results is that no hybridization occurred. Some parasites of the BI strain spontaneously changed their characteristics so that

they behaved as M strain in their inability to proliferate in the fixed tissue. They would carry with them, however, their resistance to the drug. Such a spontaneous change in strains has been reported by Haas *et al.,* 1948. In our own experience, the BI strain when mosquito passaged has changed once as a result of, or coincident with, the inoculation of a single oocyst, but it changed to a strain which still persisted in the fixed tissues though it produced normal erythrocytic parasites (Trembley *et al.,* 1951).

The results strongly suggest a genetic transfer of drug-resistance from one strain of *P. gallinaceum* to another. If this is true, then the mechanism controlling such factors as persistence of the parasite in the fixed tissues and possibly the rate of gametocyte production are controlled by many genes or by non-genetic factors, or both.

SUMMARY

Chicks were inoculated intravenously with erythrocytic parasites of the M strain and a pyrimethamine-resistant BI substrain of *Plasmodium gallinaceum.* Mosquitoes were fed on such chicks and two lines of passage were established. In one line, chicks with F_1 infections exhibited *no* late tissue forms in brain smears and the F_2 parasites were not significantly resistant to pyrimethamine. In the second line, chicks with the F_1 infections exhibited late tissue forms of the parasite, and parasites of the F_2 and F_3 infections were significantly resistant to pyrimethamine and exhibited no late tissue forms. In two series there was no evidence of the spontaneous occurrence of drug resistance in pure M strain infections not previously exposed to pyrimethamine. Nor was there any evidence of drug resistance in infections derived, by passage through mosquitoes, from M-strain parasites which broke through therapy.

REFERENCES

COATNEY, G. R., COOPER, W. C., AND TREMBLEY, H. L. 1945 Studies on *Plasmodium gallinaceum* Brumpt. III. The incidence and course of the infection in young chicks following the subcutaneous inoculation of pooled sporozoites. Am. J. Hyg. **42:** 323–329.

———, ———, EDDY, N. B., AND GREENBERG, J., 1953 Survey of antimalarial agents. Chemotherapy of *Plasmodium gallinaceum* infections; toxicity; correlation of structure and action. Public Health Monograph No. 9, U. S. Government Printing Office, Washington, D. C.

GREENBERG, J., AND TREMBLEY, H. L. 1954 Infections produced by mixed strains of *Plasmodium gallinaceum* in chicks. J. Parasit. **40:** 336–340.

———, COATNEY, G. R., AND TREMBLEY, H. L. 1954 The effect of pyrimethamine on the BI strain of *Plasmodium gallinaceum.* Am. J. Trop. Med. & Hyg. **3:** 665–171.

——— AND BOND, H. W. 1954 Resistance of a pyrimethamine-resistant strain of *Plasmodium gallinaceum* to certain 2,4-diamino-pyrimidines and related compounds. J. Parasit. (In press).

HAAS, V. H., WILCOX, A., LAIRD, R. L. EWING, F. M., AND COLEMAN, N. 1948 Symposium on exoerythrocytic forms of malarial parasites. VI. Response of exoerythrocytic forms to alterations in the life-cycle of *Plasmodium gallinaceum* J. Parasitol. **34:** 306–320.

TREMBLEY, H. L. AND GREENBERG, J. 1954 Further studies on the hybridization of strains of *Plasmodium gallinaceum.* J. Parasit. **40:** 475–479.

———, GREENBERG, J., AND COATNEY, G. R. 1951 Strain differences in *Plasmodium gallinaceum* Brumpt. II. Experiences with the sporozoite and single oocyst passage of the BI strain. J. Nat. Malaria Soc. **10:** 68–75.

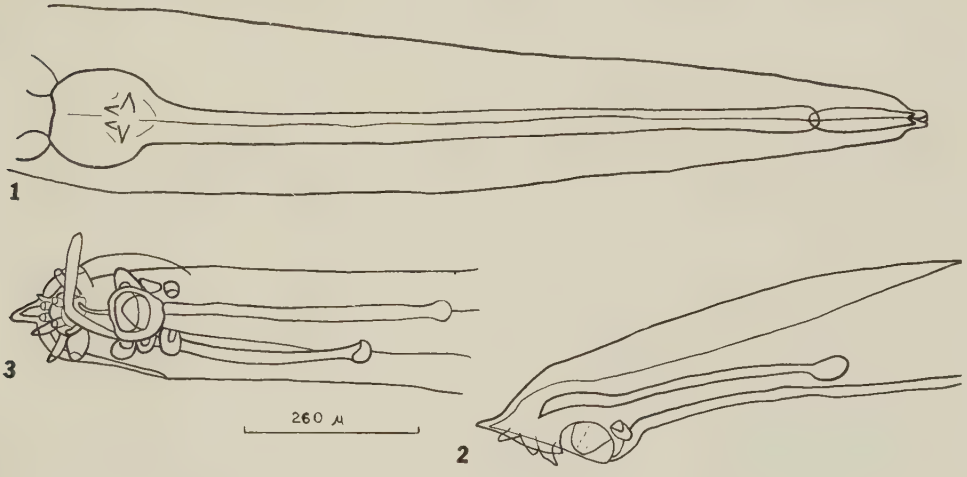
A NEW SPECIES OF *STRONGYLURIS* (NEMATODA) FROM A SOUTHERN CALIFORNIA LIZARD

ALVIN ROTHMAN

Department of Zoology, University of California at Los Angeles

In a comprehensive review of the genus *Strongyluris,* Harwood (1935) described two new species, *S. media* and *S. rubra;* and presented a key to the known species. Since Harwood's study, additional species of *Strongyluris* have been described. These are *S. bengalensis* by Chakravorty, 1936; *S. similis* by Caballero, 1938; *S. karawirensis* by Karve, 1938; *S. gonyocephali* and *S. tridentata* by Kreis, 1938; *S. meridionalis* by Kreis, 1940; *S. ranae* by Reiber, Byrd and Parker, 1940; *S. acaudata* by Caballero, 1941; *S. davisi* by Harwood, 1947; and *S. riversidensis* by Edgerly, 1952.

While engaged in studies on *Uta stansburiana stejnegeri* Mr. Don Bruce of this



DESCRIPTION OF FIGURES

FIG. 1. Pharyngeal region.
FIG. 2. Side view of male tail.
FIG. 3. Ventral view of male tail.

department recovered nematodes from the intestine. These worms apparently represent a new species of the genus *Strongyluris.* Appreciation is expressed to Mr. Bruce for making the material available and to Dr. Clark P. Read, under whose direction the work was carried out.

Strongyluris readi n. sp.

Specific diagnosis: Body fusiform having faint cuticular striations. Three fleshy lips set off by prominent constriction from rest of body. Somatic papillae absent.

Male: 8.20 mm. to 8.80 mm. long and .346 to .400 mm. wide. Length of pharynx 1.008 to 1.140 mm. Length of bulb .106 to .146 mm. Width of bulb .133 to .146 mm. Distance from nerve ring to anterior end .173 to .292 mm. Length of tail spike .040 mm. Spicule .560 mm. long and .013 mm. wide. Nine pairs of caudal papillae present, 3 lateral to sucker and 6 compactly grouped a short distance behind sucker.

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Female: 7.85 to 8.55 mm. long and .400 to .411 mm. wide. Pharynx 1.260 to 1.270 mm. long. Bulb .152 to .160 mm. long by .160 mm. wide. Filiform portion of tail .040 mm. long. Vulva 5.1 to 5.6 mm. from anterior end. Eggs (in utero) .053 mm. long by .040 mm. wide.

Host: Uta stansburiana stejnegeri Schmidt

Habitat: Intestine

Location: Borrego Valley, San Diego County, California

Types: U. S. National Museum Helm. Coll. No. 49092.

DISCUSSION

Strongyluris readi keys out to *S. media* in the key of Harwood (1935). It differs from *S. media* in being shorter, having a shorter pharynx, a smaller pharyngeal bulb and having shorter spicules and smaller ova. It is very similar to *S. media* in the arrangement of the caudal papillae. However, the distance from the sucker to the cloaca seems to be greater in my specimens than in the specimen figured by Harwood (1935).

The arrangement of the caudal papillae of *S. davisi* Harwood (1947) is also similar to that of *S. readi,* but *S. davisi* has larger ova and larger spicules and is a larger animal.

Bibliography

Caballero y C, E. 1938 Nematodes of the reptiles of Mexico II. Ann. Trop. Med. and Parasitol. **32**: 225–229.

————1941 Nematodas de los reptiles de México VI. Descripción de dos nueves species. Rev. Med. Trop. y Parasitol. **7**: 31–35.

Chakravorty, G. K. 1936 A new nematode *Strongyluris bengalensis* n. sp., with a note on the genus. Ztschr. Parasitenk. **8**: 542–545.

Edgerly, R. H. 1952 Two new species of Nematoda, *Strongyluris riversidensis* and *Pharyngodon mearnsi,* from lizard, *Streptosaurus mearnsi.* Trans. Amer. Micro. Soc. **71**: 288–292.

Harwood, P. D. 1935 Notes on Tennessee helminths II. Two new species of Strongyluris Nematoda and notes on the genus. J. Tenn. Acad. Sc. **10**: 131–141.

————1947 *Strongyluris davisi* from the stomach of a lizard *Diporiphora australis.* Proc. Linn. Soc. New South Wales. **72**: 311–312.

Karve, J. N. 1938 Some nematode parasites of lizards. Livro Jub. Prof. Travassos, pp. 251–258.

Kreis, H. A. 1938 Beiträge zur Kenntnis parasitischer Nematoden VIII. Neue parasitiche Nematoden aus dem Naturhistorischen Museum Basel. Zentralbl. Bakteriol. Abt., Orig., **142**: 329–352.

————1940 Beiträge zur Kenntnis parasitischer Nematoden IX. Parasitische Nematoden aus dem Naturhistorischen Museum Basel. Zentralbl., Bakteriol., Abt., Orig., **145**: 163–208.

Reiber, R. J., Byrd, E. E., Parker, M. V. 1940 Certain new and already known nematodes from amphibia and reptilia. Lloydia **3**: 125–144.

ACANTHOCEPHALAN PARASITES OF THE GENUS *NEOECHINORHYNCHUS* IN NORTH AMERICAN TURTLES WITH THE DESCRIPTIONS OF TWO NEW SPECIES

R. M. Cable and W. B. Hopp

Department of Biological Sciences, Purdue University, Lafayette, Indiana

INTRODUCTION

Acanthocephalans of the genus *Neoechinorhynchus* are common parasites in North American turtles and have been reported on several occasions as *Neoechino-*

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rhynchus emydis (Leidy), the only species thus far named from those hosts. Over a period of several years, numerous turtles from ponds and streams near Lafayette, Indiana, have been examined and until recently, but two species, the cooter (*Pseudemys scripta elegans*) and the map turtle (*Graptemys geographica*), have been found to harbor mature adult acanthocephalans. From almost the beginning of these observations, it was evident that each of these turtles has its own species of *Neoechinorhynchus*.

In February, 1954, a painted turtle, *Chrysemys picta marginata,* was taken from a nearby pond and found to harbor two adult acanthocephalans, a male and a female. Although superficially more like the species occurring in *G. geographica* than the one in *P. s. elegans,* this pair of worms proved on further study to represent yet another species, making a total of 3 that parasitize as many species of turtles collected within a very limited area.

Although we have had no difficulty at all in distinguishing these acanthocephalans, the question as to which if any of them is to be identified as *N. emydis* has proved to be quite another matter. Leidy's (1851) original description of *N. emydis* is so brief as to apply equally to 2 of the species we have observed, so far as morphology is concerned, and there are marked discrepancies in later descriptions of material identified as *N. emydis*. Furthermore, Van Cleave and Bullock (1950) have concluded, evidently from a large amount of such material, that *N. emydis* is the only species of Acanthocephala occurring in North American turtles. Unfortunately, their detailed study was limited to the praesoma which is almost identical in the forms which we consider to be 3 distinct species. Their general remarks on length of the worms and the hosts in which they occur indicate, however, that Van Cleave and Bullock were dealing with at least 2 and perhaps all 3 of the species which we recognize. It should be stated that acanthocephalans are very small when they enter their definitive hosts and the size differences ultimately attained by distinct species of a genus such as *Neoechinorhynchus* may be masked by the overlapping dimensions that may be observed after the parasites become functionally mature but continue to grow. Also, little is known concerning the rate of growth in different species of potential hosts or the ultimate size that might be attained within them. Furthermore, the processing of specimens for whole mounts, especially clearing, alters the size and appearance of the shelled embryos within the female and overallowance for these effects may have led to dismissal of differences in eggs as being of no significance. Thus may have been missed the most convincing and by all odds the most rapid and convenient means of differentiating the species we have studied as Text-Fig. 1 demonstrates.

In view of the evident host specificity of these parasites, Leidy's (1851) original description of *N. emydis,* brief as it is, assumes considerable significance. In that account, he described *N. emydis* from the geographic turtle *only* and gave a length well within the limits we have observed in the species from that same host. Later, Leidy (1856) renamed the species *Echinorhynchus hamulatus* for no apparent reason, listed 4 species of turtles as hosts, and gave a size limit significantly larger than that shown by any of our numerous specimens from *G. geographica*. It thus seems more than likely that the revised description and host list given in the later paper was based on more than one species of *Neoechinorhynchus*. In a recent paper (Hopp, 1954), the species that occurs in *G. geographica,* the sole host listed in

Leidy's original account, has accordingly been identified as *Neoechinorhynchus emydis* (Leidy, 1851). The other 2 species are here described as new.

DESCRIPTION OF SPECIES

(All measurements are in millimeters)

Neoechinorhynchus pseudemydis sp. nov. (text-fig. 1a and figs. 1–3)

Diagnosis: With the characters of the genus *Neoechinorhynchus*. Trunk very long and slender, curved ventrally but not strongly so. Proboscis 0.149–0.180 long and 0.198–0.240 wide. Proboscis hooks in 3 circlets of 6 hooks each, arranged quincunxially. Lateral hooks of anterior circlet distinctly posterior to, and larger than, other anterior hooks, measuring 0.085–0.106 long; paired laterodorsal and lateroventral hooks of anterior circlet 0.067–0.096 long. Hooks of middle circlet all much alike, measuring 0.050–0.060 long. Lateral hooks of basal circlet 0.028–0.034 long, remaining hooks of that circlet 0.042–0.050 long. Other measurements given in Table 1. Posterior end of female characteristic in shape, tapering from about level of uterus, cleft at tip and terminating in 1 pair of lateral lobes, always present but more pronounced in specimens cleared without puncturing. Eggs with easily lost delicate outer shell membrane; middle membrane completely enclosing embryo and rather uniformly provided with numerous radial, tube-like structures.

Host: Pseudemys scripta elegans (Wied.)

Locality: Tippecanoe River, Indiana, U. S. A.

Type specimens: 1 female holotype and 1 female and 3 male paratypes. No. 49,100. Helminthological Collection, U. S. National Museum.

Neoechinorhynchus chrysemydis sp. nov. (text-fig. 1b, figs. 4–7).

Diagnosis: Based on 2 specimens, mature male and female; species of moderate size and with characters of genus *Neoechinorhynchus*. Proboscis 0.132–0.170 long and 0.20–0.207 wide. Proboscis hooks arranged as in preceding species. Lateral hooks of anterior circlet 0.080–0.140 long, others of that circlet 0.048–0.082 long. Hooks of middle circlet 0.044–0.061 long. Lateral hooks of basal circlet 0.021–0.026 long, others 0.038–0.048 long. Other measurements given in Table 1. In female specimen, posterior end of trunk not tapered as in preceding species, rounded at tip without being cleft. Near genital pore a conspicuous papilla during life and after preparation as whole mount. Fully formed eggs within whole mount refractory to staining and considerably smaller than living ones, measuring 0.045–0.050 long. Shell elongate, with polar thickenings of middle membrane giving living eggs appearance of having swollen ends. At each pole, thin outer membrane closely applied to second one which shows a few scattered tubular structures. Indistinct line running lengthwise of the shell may be raphe along which shell splits on hatching. Living acanthor 0.028–0.030 long and 0.008–0.009 wide. In side view, egg somewhat curved and slightly narrower.

Host: Chrysemys picta marginata Agassiz.

Locality: Kolb's Pond, near Lafayette, Indiana, U. S. A.

Type specimens: female holotype and male allotype. No. 49099, Helminthological Collection, U. S. National Museum.

After removal from the host, the pair of worms was placed in water and chilled until turgid. Before fixation, however, the female was punctured to obtain living embryos and as a result, the specimen contracted ventrally and partly withdrew the proboscis. Thus if the worm had not been punctured, the trunk length probably would have exceeded that given in Table 1 although that length was determined by measuring close to the outer (dorsal) curvature.

DISCUSSION

The present study has prompted a critical re-study of the species considered to be *N. emydis* with the result that some additional features of specific value have become evident. Such characters have been incorporated in Table 1 and some may be observed by comparing fig. 8 with figs. 2 and 5. For other features of *N. emydis* see Hopp (1954).

Data concerning the praesoma are not repeated in the table because that region

of the body is much alike in all 3 species. It was observed, however, that in *N. pseudemydis* and *N. graptemydis* the lateral proboscis hooks of the basal circlet were appreciably shorter than others of that circlet whereas that difference is hardly noticeable in *N. emydis*. On the whole, however, there is considerable variation in the size of proboscis hooks in all 3 species. This variation and difficulties in measuring due to foreshortening and the fine, almost imperceptible tips of all except the anterior hooks make the proboscis armature far less decisive than other characters in differentiating the species. In respect to size, *N. pseudemydis* is much the longer of the 3, attaining a trunk length almost twice that observed in the other 2 species. Thus in referring to "adult females at times approaching 40 mm. in length" and in listing *P. s. elegans* as one of the hosts of *"N. emydis,"* Van Cleave and Bullock (1950) probably had among their material specimens of *N. pseudemydis*. Furthermore, their listing of the painted turtle as another host of *"N. emydis"* indicates that they may have had *N. chrysemydis* as well. Their statement (p. 289) "members of the genus *Chrysemys* (painted turtles) are but rarely infected by *N. emydis* in the

TABLE 1.—*Comparison of species of* Neoechinorhynchus *from turtles (All measurements in millimeters)*

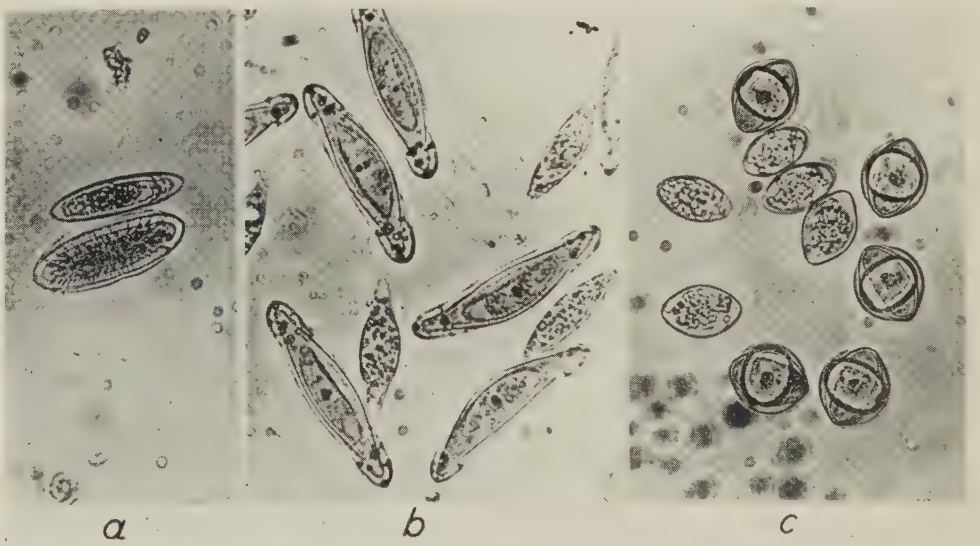
Species	*N. emydis*	*N. pseudemydis*	*N. chrysemydis*
Male			
trunk length	up to 14.5	up to 26.4	12.9
percentage occupied by reprod. system	42–50%	35–42%	48%
trunk width	up to 1.04	up to 0.83	0.68
anterior testis length	0.90–1.04	1.85–2.14	0.98
width	0.29–0.30	0.40–0.44	0.19
posterior testis length	0.88–0.93	2.60–2.90	0.81
width	0.31–0.36	0.43–0.45	0.19
Female			
trunk length	up to 22.2	up to 38.5	13.7
width	up to 1.25	up to 1.25	0.73
uterus width	0.46–0.91	0.10–0.15	0.096
posterior end	irregular	bilobed	rounded
caudal papilla	absent	absent	present
Eggs measured	living	preserved in alcohol	living
length	0.023–0.025	0.042–0.051	0.055–0.060
width	0.015–0.019	0.018–0.022	0.019–0.022
Host	*Graptemys geographica*	*Pseudemys scripta elegans*	*Chrysemys picta marginata*

northern states but harbor this parasite in some southern states . . ." is in agreement with what we have observed concerning *N. chrysemydis*. Over the years, numerous *Chrysemys marginatus* from Central Indiana northward have been examined without finding an acanthocephalan until recently when the pair of *N. chrysemydis* was discovered. That species thus is presumed to be one that is more abundant farther south.

As but a single female of *N. Chrysemydis* is available, it may be that the caudal papilla of that specimen is an anomaly. The worm was removed unharmed from the host, however, and the papilla was prominent both before fixation and after preparation as a whole mount. *N. emydis* and *N. pseudemydis* differ consistently and distinctively in the contour of the posterior end and the width of the uterus in the female as shown in figs. 2 and 8. Differences in males of the 3 species are not as obvious but nevertheless exist. The portion of the trunk occupied by the reproductive system is significantly less in *N. pseudemydis* than in the other species and the anterior testis is smaller than the posterior, whereas the reverse is true in *N. emydis* and *N. chrysemydis*. Also, the testes are much the largest in *N. pseudemydis*, even in young males corresponding in size to large males of the other species.

In *N. emydis* and *N. chrysemydis*, the lengths of corresponding testes are about the same but the testes are much narrower in *N. chrysemydis* or at least in the single specimen which is about the size of an average mature male of *N. emydis*.

Collectively these differences and especially those in the shelled embryos or eggs can scarcely be attributed to variation of a single species as it might develop in different hosts. As a rule, an intestinal helminth that can deveolp to normal maturity in a host produces viable eggs of a size, shape, and structure typical of its species. In an unfavorable host, obviously abortive and abnormal eggs are often produced if the worm does not, indeed, remain in a juvenile state until eliminated from that host. In females of all 3 species recognized by us, eggs were abundant, completely formed, and viable as indicated by the presence of acanthors in them. Yet such striking differences in these eggs are shown in text-fig. 1 as alone to provide confirmation and rapid identification of the 3 species.



TEXT-FIG. 1. Photomicrographs of shelled embryos of (a) *Neoechinorhynchus pseudemydis*, (b) *N. chrysemydis*, and (c) *N. emydis*. All to same scale.

It is evident that distinct species of *Neoechinorhynchus* can be much alike in the structure of the praesoma and that such features as size of proboscis hooks are more variable within a species than are other characters which are more easily and more accurately observed and hence of greater value in determining species. It is further evident that characteristics of the shelled embryos cannot be observed satisfactorily through the body wall of the female in a whole mount. Plainly, the study of living embryos is indicated, or if that is not feasible, of embryos removed from preserved worms.

So far as can be determined from existing descriptions, none of the species found by us in turtles is referable to any form that has been reported from fishes which serve as hosts for the great majority of described species of *Neoechinorhynchus*. If, as our observations indicate, the acanthocephalans of turtles are so host specific that the form occurring in one species of turtle does not develop to maturity in another, it seems very unlikely that a species that occurs in a fish would attain maturity also in a turtle. As a matter of fact, there is some indication that the

acanthocephalans of fishes may be more host specific than is generally supposed. Until 1931, only 4 species of *Neoechinorhynchus* were reported from freshwater fishes in the United States, but since that time 9 more have been recognized and errors of determination have been corrected. Certainly, the present study suggests that the lists of varied fishes in which some species of *Neoechinorynchus* are reported to occur are to be viewed with considerable skepticism.

All evidence supports the generally accepted view that the Acanthocephala constitute a very ancient phylum of parasites adapted to live as adults in the intestines of vertebrates. This long association with a very uniform environment may account for the lack of obvious morphological differences between species as is so evident, for example, in the praesoma of the genus *Neoechinorhynchus*. Yet this situation would be expected to lead to a considerable degree of host specificity and to speciation to an extent that may be masked by morphological similarities. It thus seems likely that there may still be unrecognized species of *Neoechinorynchus* in both fishes and turtles. So far as the latter group is concerned, the acanthocephalan that Bravo-Hollis (1946) described as *N. emydis* from *Chrysemys ornatus* in Mexico may well be such a species.

SUMMARY

Two new species of *Neoechinorhynchus* are described from turtles in Indiana, *N. pseudemydis* from *Pseudemys scripta elegans* and *N. chrysemydis* from *Chrysemys picta marginata*. The species recognized as *N. emydis* has been found as mature adults only in *Graptemys geographica*. Of particular value in distinguishing these species are the shelled embryos, especially living ones. It is suggested that species of *Neoechinorhynchus* may have a higher degree of host specificity than heretofore supposed.

Literature Cited

Bravo-Hollis, M. 1946 *Neoechinorhynchus emydis* (Leidy, 1852), Van Cleave, 1913, parasito del intestino de *Chrysemys ornata*. An. Inst. Biol. Univ. Nac. México **17**: 187–192.

Hopp, W. B. 1954 Studies on the morphology and life cycle of *Neoechinorhynchus emydis* (Leidy), an acanthocephalan parasite of the map turtle, *Graptemys geographica*. J. Parasit. **40**: 284–299.

Leidy, J. 1851 Contributions to helminthology. Proc. Acad. Nat. Sci. Phila. (1850–1851) **5**: 205–209.

————1856 A synopsis of Entozoa and some of their ectocongeners observed by the author. Proc. Acad. Nat. Sci. Phila. **8**: 42–58.

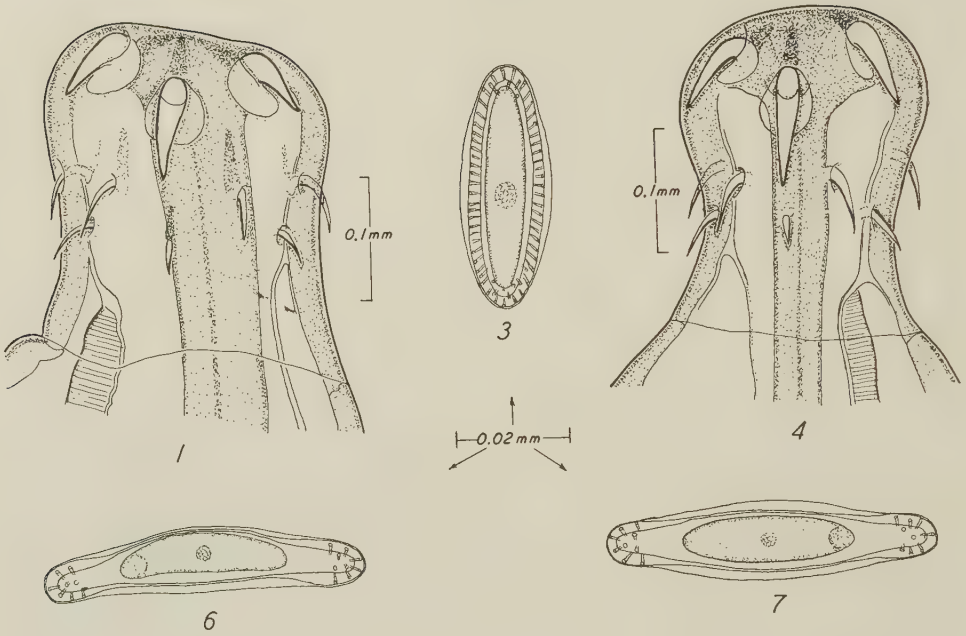
Van Cleave, H. J. and Bullock, W. L. 1950 Morphology of *Neoechinorhynchus emydis*, a typical representative of the Eoacanthocephala. I. The praesoma. Tr. Am. Micr. Soc. **69**: 288–308.

Explanation of Plate

Abbreviations: cp, caudal papilla; om. ovarian mass; sa, so-called selector apparatus; ub, uterine bell; ut, uterus; va, vagina; vs, vaginal sphincter.

Fig. 1. *Neoechinorhynchus pseudemydis*, praesoma in lateral view.
Fig. 2. Same, posterior end of female in semi-lateral view.
Fig. 3. Same, shelled embryos from preserved female.
Fig. 4. *Neoechinorhynchus chrysemydis*, praesoma of male (allotype) in lateral view.
Fig. 5. Same, posterior end of female (holotype) in lateral view.
Fig. 6. Same, shelled embryo in "lateral" view.
Fig. 7. Same, shelled embryo in "frontal" aspect.
Fig. 8. *Neoechinorhynchus emydis*, posterior end of female in lateral view.

PLATE I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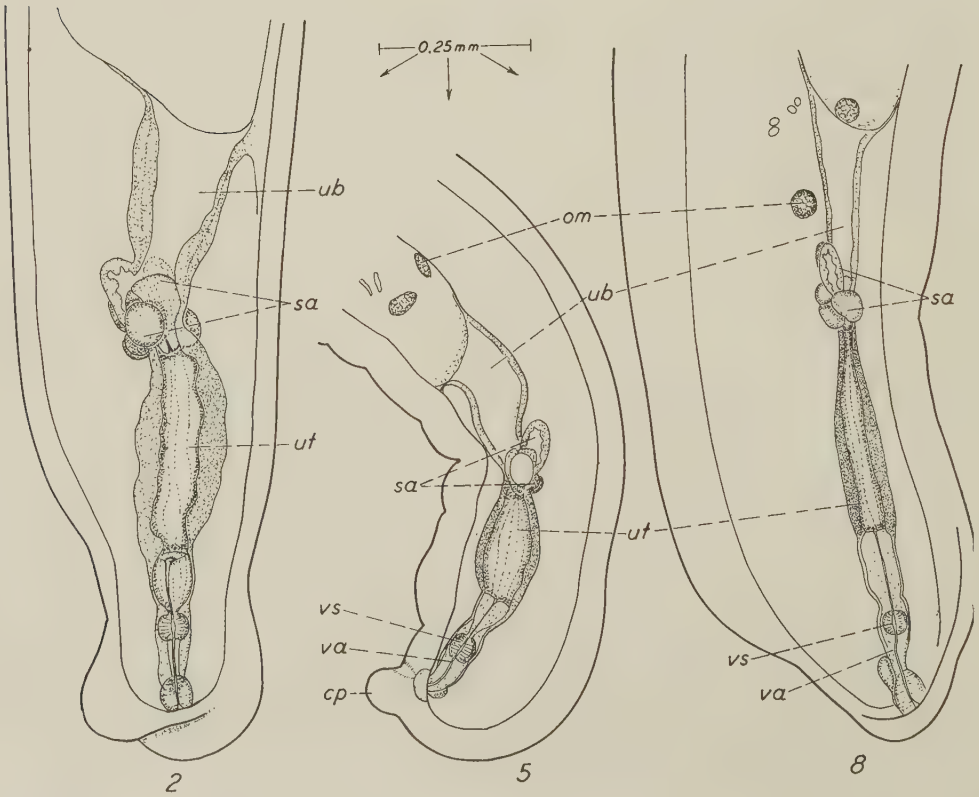
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A LUNGWORM, *ANGIOSTRONGYLUS BLARINI*, N. SP., FROM THE SHORT-TAILED SHREW, WITH OBSERVATIONS ON THE HISTOPATHOLOGY AND LIFE CYCLE[1]

ROBERT E. OGREN

Several individuals from a series of Short-tailed Shrews, *Blarina brevicauda*, collected in Champaign County, Illinois during the fall of 1950, 1951, 1952, were found to harbor a new species of lungworm (NEMATODA: METASTRONGYLIDAE). The purpose of this paper is to present a brief description of the new species and to record certain limited observations on the histopathology of the infections and the life cycle of the parasite. The encouragement and advice of Dr. Lyell J. Thomas are gratefully acknowledged.

Angiostrongylus blarini, n.sp.

(All measurements in millimeters.)

Male: length, 3–4; width, 0.043–0.083; esophagus, length, 0.157–0.198; nerve ring to lips, 0.056–0.082; spicules, slender, slightly curved, length, 0.066–0.099; no gubernaculum found. Bursal ray formula: ventral ventrals and lateral ventrals, short, knoblike and fused nearly to their tips; the reduced external laterals, medial laterals and posterior laterals fused nearly to tips; external dorsals, slender and finger like; right and left dorsals fused to form an inverted T-shaped appendage (Figs. 1, 2, 3).

Female: length, 9.5–14.0; width, 0.066–0.106; esophagus, length, 0.191–0.197; width, 0.017; nerve ring to lips, 0.066–0.093 (Fig. 4); anus subterminal; vulva to tail length, 0.138–0.281; eggs, embryonic development occurring after elimination; length, 0.033–0.036; width, 0.020–0.023 (Figs. 5, 6, 7). Intestine containing numerous red blood cells (Fig. 4), with the intestinal cells filled with dark, red-brown to black spheroids, or sphaero-crystals perhaps derived from hemoglobin (Fig. 8).

Host: Blarina brevicauda (Say).

Habitat: Lung, in cysts near bronchioles.

Type specimens: Holotype male and allotype female, U.S. Nat. Mus. Helm. Coll. No. 47831. Paratypes and slide of sectioned lung cyst, Coll. No. 47832.

Locality, dates and numbers collected: Champaign County, Illinois (type locality): October, 1950 examined 6 (positive 5); October, 1951, examined 20 (positive 2); November, 1952, examined 14, all negative. Shrews examined were those that had died in live traps used during population studies of a meadow.

Angiostrongylus blarini differs specifically from each of the 7 species of *Angiostrongylus* listed by Dougherty (1946) because of the peculiar morphology of its dorsal rays, the fused lateral rays, the very short spicules, and the small size of the adults. To the writer's knowledge this is the only lungworm described from *Blarina*, although as early as 1938 Dr. L. J. Thomas made unpublished sketches of a similar nematode from the same host.

OBSERVATIONS ON HISTOPATHOLOGY AND LIFE CYCLE

Cysts containing nematodes were found in all 5 lobes of the lungs of heavily infected shrews. Mild infections usually involved more than one lobe (Fig. 9). In October, 1950 there were 1 to 7 cysts per animal. The right lobes were most heavily infected. Each cyst contained an average of 6 adults in the ratio of 2 males to every 4 females. In October, 1951 1 to 3 cysts per host were observed.

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[1] Contribution of the Zoological Laboratory of the University of Illinois. Present address: Biology Department, Ursinus College, Collegeville, Penna.

Each contained an average of 3 adults in the ratio of 1 male to every 2 females. The white globular cysts, 3–4 mm. in diameter, bulged from the red lung surface and extended deep into the tissues. They were filled with white viscous material containing motile larvae, embryonated and non-embryonated eggs, and living and dead adults entwined throughout the substance.

One lung lobe with its contained cyst was sectioned. The cyst was located between alveolar tissue, large pulmonary blood vessels and a bronchiole with which it appeared to communicate. The thick cyst wall had 3 distinct zones. The inner zone was characterized by entrapped larvae and eggs, spindle-shaped nuclei and a few wandering cells. The intermediate zone was composed largely of compact layers of connective tissue with long spindle-shaped nuclei. Occasional

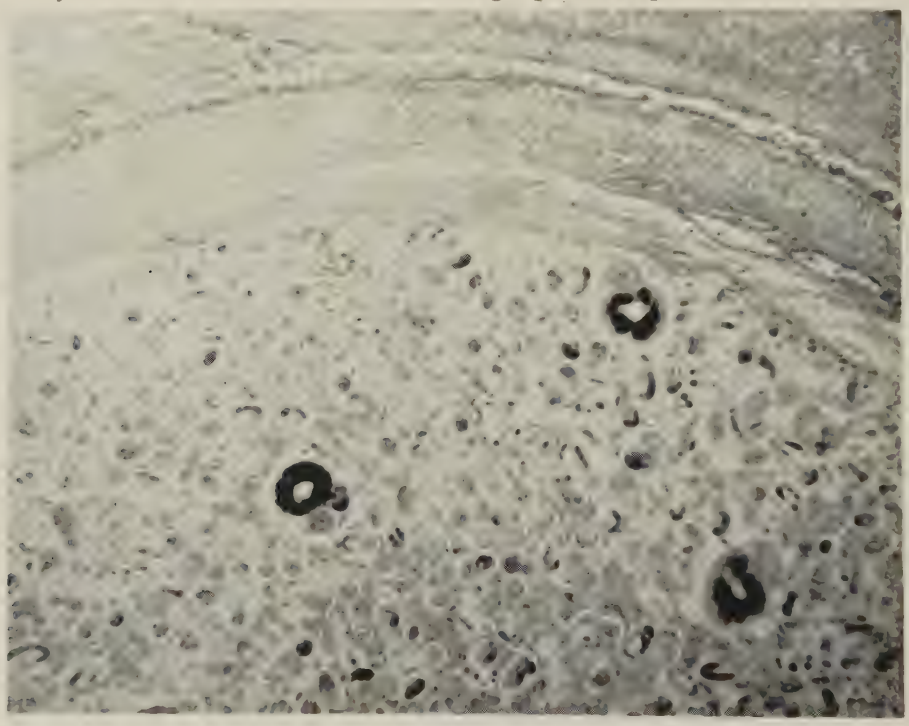


FIG. 1.—Portion of sectioned lung cyst showing connective tissue of bronchiole, cyst wall, 3 adults in cross-section, eggs and larvae.

eosinophiles and erythrocytes were found in the outer limit of this region. The outer zone, nearest the blood vessels and bronchiole, was composed of loose reticular tissue resembling the lamina propria of the bronchiole. Numerous eosinophiles, erythrocytes, fibrocytes, and mononuclear cells were present in the stroma. The thickness and uniformity of these zones varied around the cyst circumference. This was especially evident near the bronchiole. Here the thick outer connective tissue layer formed a fourth layer of the cyst wall. The wall was weak on the alveolar side. The surrounding lung tissue contained large numbers of erythrocytes, eosinophiles, mononuclear cells and polymorphonuclear cells especially in the lamina propria of the bronchioles. The lumen of the infected bronchiole was congested with red cells, eosinophiles, mucus material, epithelial cells, mononuclear cells and larvae.

Lung tissue from 3 negative *Blarina brevicauda* contained a few eosinophiles and mononuclear cells in the lamina propria in varying numbers depending on the particular shrew. The eosinophiles were more numerous in the lamina propria of large bronchioles.

The small projection from the right lung (Fig. 9), is not to be associated with the infection since it was found in all normal and infected specimens examined. It was a white finger-like appendage about 2 mm. long, supplied with blood vessels and filled with air. Careful observation revealed it to be the blind extension of two bronchioles (Fig. 10). Their thick connective tissue walls formed the main structure. A few terminal bronchioles arose here. The embryological or functional significance of this structure is not known.

The lung cysts served as incubation chambers in which the embryonic development of the first stage larvae occurred. The larvae left the shell membranes while in the cysts but did not develop further. Larvae recovered from the cysts measured 0.255–0.357 mm. long and had an indistinct esophagus (Fig. 11) and a characteristic bent tail (Fig. 12). Similar larvae recovered from the lumen of the large intestine of one shrew examined were 0.271–0.356 mm. in length; no molt was observed. It was evident that the larvae left the lung through the trachea, were eliminated orally, or swallowed and eliminated through the anus. Larvae were not able to develop or molt when placed in tap water. Under the same conditions *Dictyocaulus* sp. molted.

Young slugs, *Deroceras gracile,* 5–7 mm. long, were exposed to active larvae from lung cysts with negative results. Slugs were placed in a petri dish containing moist filter paper on which numerous larvae were active. Larvae were also placed on the surface of the slugs to entangle in the mucus. Three days later the slugs were examined under the microscope by compressing the entire slug between two slides. This technique rendered all parts clearly visible and was used later for adult slugs. Field collected specimens of *Deroceras gracile* from the contaminated meadow did not show larvae in the muscle or epithelial folds of the foot. The examination of several *Philomycus carolinianus* from the woods adjacent to the meadow, revealed larval nematodes in the foot muscle and epithelial folds. These larvae were double the length of the first stage larvae of *Angiostrongylus blarini* but had the same type of flexure of the posterior extremity (Fig. 13). The esophagus of these larvae (Fig. 14) was very similar to that of the larval and adult *A. blarini.* This suggested that these larvae constituted an infective third stage of this or some other closely related species. Hobmaier and Hobmaier (1935) demonstrated that *Aelurostrongylus* uses the epithelial folds of various slugs for development. Live specimens (Figs. 13, 14) measured in mm.: length, 0.613–0.727; greatest width, 0.023; length of slender esophagus, 0.116–0.132; genital rudiment distance behind lips, 0.399–0.427. The above larvae recovered from slugs were fed to white mice with negative results.

Literature Cited

Dougherty, E. C. 1946 The genus Aelurostrongylus Cameron, 1927 (Nematoda: Metastrongylidae) and its relatives; with descriptions of Parafilaroides, gen. nov., and *Angiostrongylus gubernaculatus,* sp. nov. Proc. Helminth. Soc. Washington **13:** 16–25.

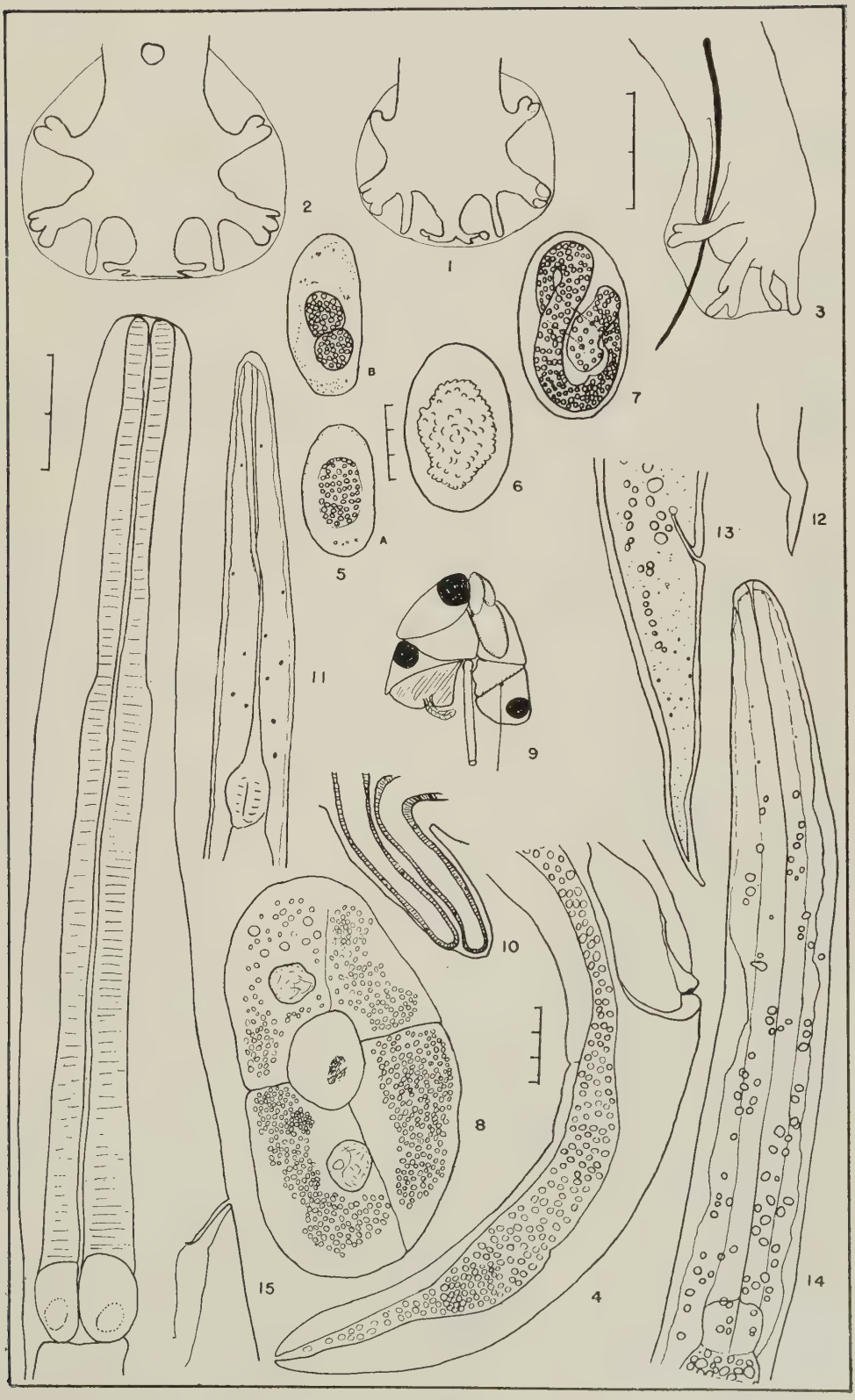
Hobmaier, M. and Hobmaier, A. 1935 Intermediate hosts of *Aelurostrongylus abstrusus* of the cat. Proc. Soc. Exper. Biol. and Med. **32:** 1641–1647.

Explanation of Plate

All figures drawn with the aid of camera lucida except Fig. 9. Each scale division represents 10 microns. Figures 1, 2, 3, 8, 11, 12, 13, 14, 15 have same scale. Figures 4–7 have same scale.

Fig. 1. Male, posterior, dorsal view, 950×.
Fig. 2. Male, posterior, ventral view, 950×.
Fig. 3. Male, posterior, lateral view, 950×.
Fig. 4. Female, posterior lateral view, 440×.
Fig. 5. Egg, unembryonated, 440×.
Fig. 6. Egg, morula, 440×.
Fig. 7. Egg, active embryo, 440×.
Fig. 8. Intestinal epithelium, cross section, female, 950×.
Fig. 9. Infected lung, ventral view showing heart, round black areas represent cysts, free hand.
Fig. 10. Finger like extension of bronchi of right lung, 10×.
Fig. 11. Active larva from cyst, anterior, 950×.
Fig. 12. Active larva from cyst, posterior, lateral view, 950×.
Fig. 13. Larva from foot of slug, posterior, lateral view, 950×.
Fig. 14. Larva from foot of slug, anterior, 950×.
Fig. 15. Adult male, anterior region, 950×.

PLATE I



THE DISTRIBUTION, LONGEVITY AND SEX RATIO OF *TRICHINELLA SPIRALIS* IN HAMSTERS FOLLOWING AN INITIAL INFECTION

ELIZABETH M. BOYD AND E. JANE HUSTON

Zoology Department, Mount Holyoke College, South Hadley, Mass.

Extensive work has been done on various aspects of trichiniasis with mice and rats as experimental hosts. Relatively few investigations on *Trichinella* have involved the hamster. Mauss (1940) used this mammal in studying the transference of immunity via the placenta and milk from parent and offspring. Recently Humes and Akers (1952) described the vascular changes in the cheek pouch of the hamster during infection by *T. spiralis*. The present study was an attempt to ascertain the susceptibility of the hamster to *Trichinella*. As viability controls mice were similarly infected with this nematode.

MATERIAL AND METHODS

Seventy two male golden hamsters, approximately 120 days old were used for this investigation. They were divided into 2 series according to the size of the infective dose of *T. spiralis*. Each of the 24 animals of series I was fed 100±5 cysts; those of series II numbering 48, were each given 500±5 cysts. The animal was infected by feeding with forceps small portions of fresh mouse diaphragm and intercostal muscles containing microscopically counted numbers of *Trichinella* cysts. The source of the material was mice that had been previously infected for not less than six weeks. The establishing of the stock supply was made possible through the kind cooperation of Drs. Bullock (University of New Hampshire), Gursch (Chicago College of Osteopathy) and Larsh (University of North Carolina). Food was removed from the cages 24 hours prior to experimental infection and before autopsy. Three animals from series I and 6 from series II were sacrificed at intervals of 1, 2 and 24 hours, 6 and 15 days, 3, 4 and 5 weeks following the initial infection (tables 1, 2).

The intestinal phase of the *T. spiralis* was determined in the animals sacrificed at periods of parasitism through the 15th day. The intestine of each host was placed in a petri dish with 1% sodium hydroxide, slit lengthwise, cut into 2 inch lengths, and refrigerated at 5° C. for a minimum of 12 hours. In series II the small and large intestines were placed in individual dishes so that separate data could be recorded for each portion. After the mucus had been dissolved the worms were counted in the intestinal wall by removing each section to a large glass slide and teasing it under a dissecting microscope. To count the worms floating in the dish, the sodium hydroxide solution was centrifuged, the supernatant fluid discarded, and the sediment transferred, a small quantity at a time, to a glass slide under the microscope and checked for *Trichinella*.

An area one cm. in length was removed from each quarter of the small intestine when the host was first dissected, fixed in Bouin's solution and sectioned to ascertain the time and degree of penetration of the *T. spiralis*.

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TABLE 1.—*Series I. Average numbers of* T. spiralis *recovered from eight groups of three hamsters each killed at periods from 1 hour to 5 weeks after an infective dose of 100 ± 5 larvae*

Duration of infection	Trichinella in intestines				Larvae in muscles	
	Female	Male	F/M ratio	% recovery	Approx. ave. no.	Ratio to dosage
1 hour	49.0	21.0	2.3 : 1	70.0	..	..
2 hours	46.0	15.0	3.1 : 1	61.0	..	..
24 hours	32.0	23.0	1.4 : 1	55.0	..	..
6 days	14.0	9.0	1.6 : 1	23.0	..	..
15 days	0.0	0.0	0 : 0	0.0	2,984	29.8 : 1
3 weeks	..	..	..	..	2,984	29.8 : 1
4 weeks	..	..	..	..	2,960	29.6 : 1
5 weeks	..	..	..	..	3,618	36.2 : 1

The animals infected for periods from 15 days to 5 weeks were examined for encysted larvae. The host was skinned, eviscerated and its carcass finely minced and digested in 25 cc. artificial gastric juice per gram of flesh at 37° C. When digestion was completed at the end of 12 hours, the material was diluted with sufficient 0.8% saline solution to double its volume and strained through two thicknesses of gauze to remove the bone. The solution was poured into the basket of an International Chemical centrifuge, that had been lined by filter paper, and centrifuged at 1800 r.p.m. for 1 minute. Four previously marked square centimeters of the filter paper were removed (2 from the base and 2 from the wall) and the larvae adhering to their surfaces counted. Since the total area of the filter paper was 296 square cm. (area of base—216 square cm.; area of side—80 square cm.), the count on the 4 square centimeters was multiplied by 74 to give the estimated number of larvae for each animal (i.e., $74 \times 4 = 296$).

RESULTS

Series I. The results of the examination of the intestine and muscles of the 24 hamsters that received a dose of 100 ± 5 cysts per hamster are given in table 1. The nematodes quickly entered the small intestine. By the end of the first hour 70 of the introduced larvae were recovered from this region of the digestive tract. This represented the maximum number found in this series of animals. The adult worms decreased thereafter, 61 being present by the end of the second hour, 55 by the end of 24 hours and finally 23 on the 6th day. Worms were absent from the intestines of the hosts killed on the 15th day, but approximately 3,000 larvae had encysted in their muscles. By the 5th week the average number of encysted larvae had increased to 3,618. During the intestinal phase of the infection females out-

TABLE 2.—*Series II. Average numbers of* T. spiralis *recovered from eight groups of six hamsters each, killed at periods from 1 hour to 5 weeks after an infective dose of 500 ± 5 larvae*

Duration of infection	Trichinella in intestines								Larvae in muscles	
	Small int.		Large int.		Entire		F/M ratio	% recovery	Approx. ave. no.	Ratio to dosage
	Female	Male	Female	Male	Female	Male				
1 hour	49.0	30.0	0.0	0.0	49.0	30.0	1.6 : 1	15.8	..	..
2 hours	161.0	90.0	0.0	0.0	161.0	90.0	1.8 : 1	50.2	..	..
24 hours	143.0	55.0	10.0	44.0	153.0	99.0	1.6 : 1	50.4	..	..
6 days	31.0	15.0	4.0	9.0	35.0	24.0	1.5 : 1	11.8	..	..
15 days	4.3	0.0	1.7	0.0	6.0	0.0	+ : 1	1.2	55,136	110.3 : 1
3 weeks	..	..	..	..	..	..	..	..	60,310	120.6 : 1
4 weeks	..	..	..	..	..	..	..	..	61,446	122.9 : 1
5 weeks	..	..	..	..	..	..	..	..	62,468	124.9 : 1

numbered males. The F/M ratio fluctuated from 1.4 : 1 to 3.1 : 1, the latter ratio being observed at the 2 hour period of infection. A microscopic study of the sectioned portions of the intestine failed to reveal any worms.

Series II. The data for the 48 hamsters receiving 500 ± 5 cysts are shown in table 2. In this series the numbers for the small and large intestines were kept separate. By the end of the first hour 15.8 percent of the worms were recovered from the small intestine and by the end of the second hour this figure rose to 50.2 percent; no worms were found at these times in the large intestine. At the 24 hour period although the total percentage recovery was 50.4 that for the small intestine was 39.6 (198 worms), and 10.8 percent (54 worms) for the large intestine. By the 6th day the number of worms had decreased considerably for both areas of the intestine—to a total percentage recovery of 11.8. This drop was even more marked by the 15th day when only 1.2 percent had survived. The hosts of the 15 day period harbored 55,136 encysted larvae (average) in their muscles. This figure gradually rose so that the hamsters in the 5th week period possessed an average of as many as 62,468 larvae. The sex ratio during the intestinal phase averaged 1.6 : 1 female to male. At the 24 hour and 6 day period, males predominated over females in the large intestine. By the 15th day only females were present in both locations of the digestive tract. Microscopic examination of serially sectioned material showed nematodes only in the mucosa of the duodenum of hamsters sacrificed at the 2nd hour period.

DISCUSSION

The course of the *Trichinella* infection in the hamster as host followed a pattern very similar to that observed in the mice used as viability controls and to that previously described in rats (Gursch, 1949). Entrance and penetration of the parasite into the small intestine was rapid. Many worms were present in the intestine at the end of the first hour. Penetration of the duodenal mucosa was observed by the end of the 2nd hour period in animals of series II. The negative findings in the majority of the sectioned portions of the intestines may be accounted for in part by the relatively light initial infection especially in hamsters of series I. The maximum number of adult worms was recovered in animals killed during the first day (tables 1, 2). In series I this was obtained at the first hour period. In animals of series II, receiving a dose of 500 ± 5 larvae, the maximum number for the small intestine alone occurred at the end of the 2nd hour period at which time none had yet reached the large intestine.

A marked reduction in number of survivors had taken place by the 6th day and this was more striking in hosts receiving the larger dose (series II). In these animals, it was evident that this elimination of worms during the first week of infection involved more males than females, since it was the males that were found in greater numbers in their large intestines. Finally by the 15th day the adult nematodes were absent in hosts of series I and only 1.2 percent were present in those of series II. All of these were females and were found in both portions of the intestines. It has been pointed out that as the infective dose is increased in rats, proportionately fewer adults become established (McCoy, 1940), but their survival time is progressively extended (Gursch, 1949). These observations have now been established in the hamster, for those receiving the heavier initial infection eliminated

proportionately more worms but they harbored the adult *Trichinella* for a longer period than the hosts that received the lighter initial dose of cysts. It would appear from the present data on the hamster that the period of stabilization in numbers of *T. spiralis* terminates during the first week of infection. However, to establish a more complete picture of the intestinal phase additional experiments should be run involving host examination on alternate days beginning with the first day of parasitism.

The sex ratio for the total number of worms collected from the intestines of all of the 72 hamsters was 1.8: 1 (F/M). This is in line with the most recent investigations on *Trichinella* by Roth (1938) and Gursch (1949). The former found the F/M ratio to be 2: 1 in guinea pigs. The latter also obtained a 2: 1 F/M ratio in rats during the 2nd to the 9th day of the infection.

The larvae that had become encysted in the muscles of the hamsters of series I by the 15th day numbered approximately 3,000. This represented a 29.8: 1 ratio of larvae to dosage. This ratio had only slightly increased, to 36.2: 1, by the 5th week. In contrast to this, hosts of series II that had received the larger initial dose, revealed a 110.3: 1 ratio by the 15th day. It increased steadily and markedly with the duration of the infection, so that by the 5th week it had become 124.9: 1. These results for the hamster are contrary to the findings of Marchant (1939) in which the yield of encysted larvae in young rats became progressively lower as the dosage was increased.

SUMMARY

1. Seventy two male golden hamsters, approximately 120 days old, were infected with *T. spiralis;* 24 with 100 ± 5 larvae (series I); 48 with 500 ± 5 larvae (series II). Three animals of series I and 6 of series II were sacrificed at periods of 1, 2 and 24 hours, 6 and 15 days, 3, 4 and 5 weeks following the initial dose.

2. Many of the *Trichinella* had entered the small intestine by the end of the 1st hour and were penetrating its mucosa by the end of the 2nd hour period. The maximum number of adult worms was recovered during the 1st day. In hamsters receiving the larger dose, the *Trichinella* were eliminated in proportionately greater numbers but they survived for a longer period. Thus in series I and II, respectively, 23.0 percent and 11.8 percent had survived by the 6th day, and 0.0 percent and 1.2 percent by the 15th day.

3. The sex ratio of the adult worms was 1.8: 1 F/M. Males were eliminated more rapidly from the hosts than the female worms.

4. The number of encysted larvae in the hosts of series I represented a 29.8: 1 and a 36.2: 1 ratio of larvae to dosage at the 15th day and 5th week. In series II, however, the ratios were 110.3: 1 and 124.9: 1 for the same periods of infection.

LITERATURE CITED

GURSCH, O. F. 1949 Intestinal phase of *Trichinella spiralis* (Owen, 1835) Railliet, 1895. J. Parasit. **35:** 19–26.

HUMES, A. G. AND AKERS, R. P. 1952 Vascular changes in the cheek pouch of the golden hamster during infection with *Trichinella spiralis* larvae. (Abstr.) J. Parasit. **38** (4—Sect. 2): 16–17.

MCCOY, O. R. 1940 Rapid loss of Trichinella larvae fed to immune rats and its bearing on the mechanism of immunity. Am. J. Hyg. **32:** 105–116.

MARCHANT, E. H. 1939 Effect of age of rat on the size of *Trichinella* infections. (Abstr.) J. Parasit. **25** (Dec. Suppl.): 23.

MAUSS, E. A. 1940 Transmission of immunity to *Trichinella spiralis* from infected animals to their offspring. Am. J. Hyg. **32**: 75–79.

ROTH, H. 1938 Experimental studies on the course of trichina infection in guinea pigs. I. The minimum dose of trichina larvae required to produce infestation of the muscles; with an account of the potential productiveness of the female trichina. Am. J. Hyg. **28**: 85–103.

ADDITIONAL DATA ON FILARIAL WORM INFECTIONS IN VERTEBRATES OF SOUTHWESTERN GEORGIA

EDWIN J. ROBINSON, JR.

Communicable Disease Center, Public Health Service, U. S. Department of Health, Education, and Welfare, Atlanta, Georgia, and Emory University Field Station, Newton, Georgia

Data are presented here of infections found in 830 animals collected near Emory University Field Station, Baker County, Georgia, from October 16, 1952, through March 15, 1954, and examined for filarial worms. Similar data from 1,237 animals, gathered through October 15, 1952, were tabulated and analyzed in a longer report (Robinson, J. Parasitol. **40**: 138–147, 1954). This note is an addendum to the factual material in that report, and concludes a survey of the local vertebrate population for filarial worms.

In the following list of animals examined, the first figure after the species name indicates the number of specimens dissected; the second, when present, the number of those infected. Microfilariae and adult worms were found together in 13 hosts, adults only in 8, and microfilariae in the remainder of the infections.

REPTILIA: *Deirochelys reticularia,* 1; *Kinosternon subrubrum,* 1; *Lampropeltis getulus,* 2; *Elaphe obsolcta confinis,* 1; *Coluber constrictor,* 1; *Thamnophis sirtalis ordinatus,* 1; *Crotalus adamanteus,* 1.

AVES: *Cyanocitta cristata,* 306/169; *Corvus brachyrhynchos,* 156/109; *C. ossifragus,* 4/2; *Lanius ludovicianus,* 5/1; *Centurus carolinus,* 14; *Melanerpes erythrocephalus,* 4; *Dendrocopus pubescens,* 5; *D. villosus,* 2; *Colaptes auratus,* 4; *Sphyrapicus varius,* 2; *Mimus polyglottos,* 5/1; *Toxostoma rufum,* 6/1; *Pipilo erythrophthalmus,* 11/1; *Zonotrichia albicollis,* 23/2; *Z. leucophrys,* 1; *Spizella passerina,* 15; *S. pusilla,* 3; *Melospiza georgiana,* 1; *Passerculus sandwichensis,* 2; *Poaecetes gramineus,* 2; *Richmondena cardinalis,* 38/5; *Thryothorus ludovicianus,* 2/1; *Sialia sialis,* 4/3; *Hylocichla ustulata,* 2; *Turdus migratorius,* 2/1; *Polioptila caerulea,* 4; *Regulus satrapa,* 2; *R. calendula,* 3; *Vireo olivaceus,* 2; *V. flavifrons,* 1/1; *Parula americana,* 8; *Dendroica coronata,* 1; *D. pinus,* 2/1; *Piranga rubra,* 6/2; *Parus bicolor,* 5; *P. carolinensis,* 1; *Tyrannus tyrannus,* 3/2; *Myriarchis crinitus,* 3; *Sayornis phoebe,* 1; *Butorides virescens,* 1; *Casmerodius albus egretta,* 1; *Florida caerulea,* 1; *Buteo lineatus,* 2; *B. jamaicensis,* 1; *Falco sparverius,* 1; *Accipiter striatus velox,* 1; *Columbigallinae passerina,* 1; *Zenaidura macroura,* 2; *Passer domesticus,* 1; *Strix varia,* 2; *Gallus domesticus,* 1; unidentified, 4.

MAMMALIA: *Urocyon cinereoargenteus,* 11; *Vulpes fulva,* 4; *Procyon lotor,* 26/13; *Didelphis virginiana,* 30; *Mus musculus,* 4; *Sigmodon hispidus,* 2; *Peromyscus gossypinus,* 7; *Lasiurus seminola,* 1; *Felis domesticus,* 10; *Canis familiaris,* 4/1; *Sylvilagus floridanus mallurus,* 28; *S. palustris,* 2/1; *Sciurus niger,* 4; *S. carolinensis,* 3; *Glaucomys volans saturatus,* 3; *Mephitis m. elongata,* 2/2; *Spilogale putorius,* 1.

The only species listed here as infected which were not included in the previous report were the fish crow, *Corvus ossifragus,* and the robin, *Turdus migratorius.* The only species recorded as uninfected in the earlier report and listed in this one as infected are the pine warbler, *Dendroica pinus,* the raccoon, *Procyon lotor,* and the marsh rabbit, *Sylvilagus palustris.*

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No new facts concerning the distribution and biology of the parasites were discovered in the study of these specimens, except those relating to an epizootiological study of filarial worms in corvid birds. All the microfilariae in this, as in the initial collection, were undifferentiated and without spines, and so belong to the family DIPETALONEMATIDAE. Relatively few adult worms were found; except for one from *Dendroica pinus* and three from *Sylvilagus palustris,* all were from blue jays (*Cyanocitta cristata*). Nineteen of these birds contained adult dipetalonematids, in association with microfilariae in 12 instances.

Numerous cases of infection of individual bird hosts with two microfilarial species were discovered, and raccoons harbored 3 species, sometimes with 2 of them being in a single host. The details of these infections will be given in a report on the morphology and identity of all the microfilariae collected. Particularly interesting was a triple infection in a single kingbird (*Tyrannus tyrannus*), the only such multiple infection found. Infections of crows (*Corvus brachyrhynchos*) with microfilariae normally found in jays were not uncommon. Twenty-eight of the 109 infected crows harbored this type of larva, 20 of these infections being in combination with the typical crow microfilarial parasite. Only 2 of the infected jays contained crow microfilariae. It appears that physiological specificity of filarial worms for avian hosts is not always absolute. The apparent specificity which often prevails possibly is due to ecological relationships between the vectors and the birds.

None of the 31 additional woodpeckers examined were infected. Infections in only 7 of the grand total of 185 specimens show that, in the area surveyed, filarial infections generally are absent from this avian family. Their absence could be due to a relative immunity to infection, but it might be speculated that peculiarities of habits of woodpeckers prevent their exposure to suitable vectors, except in rare instances.

LABORATORY OBSERVATIONS ON THREE SPECIES OF BIRD MITES

ROBERT K. SIKES AND ROY W. CHAMBERLAIN

From the Communicable Disease Center, Public Health Service,
U. S. Department of Health, Education, and Welfare, Montgomery, Ala.

Wood (1917) recorded the life history and habits of *Dermanyssus gallinae* (De Geer). In a subsequent report (1920) he described portions of the life cycle and control of *Bdellonyssus sylviarum* (Canestrini and Fanzago), although at the time he believed he was working with *B. bursa* (Berlese). Cameron (1938) reviewed the knowledge of *B. sylviarum* and *B. bursa* and included his own biological observations. These observations were somewhat limited, however, by his inability to rear *B. sylviarum* beyond the protonymph stage.

The present report, based upon three years' observations of laboratory colonies of these three species of mites under controlled conditions, supplements such previous work. Included in this study are observations on general behavior in laboratory colonies, life cycles, feeding habits, sizes and weights of different stages, volumes of blood ingested, and results of feeding adults upon abnormal hosts.

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MATERIALS AND METHODS

Mite maintenance. The strains of mites used have been maintained in laboratory colonies since 1949. The *B. sylviarum* were originally collected in Fort Scott, Kansas, and the *D. gallinae* in Colorado, both by Mr. Virgil I. Miles. The *B. bursa* were collected near Montgomery, Alabama.

Rearing methods for these mites have already been described (Chamberlain and Sikes, 1950). The rearing chambers were moated metal boxes packed with fine hay in the bottoms to simulate nest material. Young chicks, usually less than one week old, served as hosts, except in the abnormal-host studies. The room in which the mites were kept was maintained at 80–83° F. and 60–70 percent relative humidity.

Life cycle studies. To obtain engorged mites for the life cycle studies, hungry specimens from the colonies were released upon immobilized one-day-old chicks in 10-inch battery jars and the room darkened. Inspections were made at approximately 2-hour intervals and fully engorged specimens selected by aspirator. These mites were isolated in small glass tubes plugged with black-dyed cotton and were examined periodically. Most of the eggs were laid on the black cotton, which simplified finding and counting.

Adults of known age and history were obtained by mass feeding of protonymphs and rearing of selected specimens.

Measurements and weights. Measurements of mites include only the body lengths and widths, exclusive of mouthparts and legs. Mean weights of individual mites were calculated by weighing pools of known numbers of specimens.

Animal host studies. Mites in the abnormal host feedings were confined in cardboard cells on the skin of chickens, mice, rabbits and man. A portion of the top of each cell was cut out and covered over with 130-mesh bolting silk for ventilation.

EXPERIMENTAL

Observations of behavior in colonies:

Bdellonyssus bursa. This species feeds readily on chicks either in the dark or in the half-light of the rearing chamber. When the population is high, mites are found on all parts of the chick body, but a preferred site of feeding is on the head, especially around the eyes and beak. Feedings are usually completed within a few minutes, after which most of the specimens crawl away from the chick.

The behavior of the mites subsequent to feeding depends upon the degree of engorgement attained. Mites taking only a partial meal do not produce eggs, but, when disturbed, wander aimlessly over the litter and the sides of the chamber. Often it is possible to collect thousands of partially engorged specimens of uniform size from a colony shortly after a chick has been introduced. This may be taken as evidence of a high population of young adults, as they usually take partial meals for their first, and often for their second, feedings. However, completely engorged females crawl down into the litter of the chamber to oviposit. Within 2 or 3 days, pale white protonymphs appear, which cluster on the sides of the chamber and on the highest tufts of grass stems if no chick is available for them to feed upon.

Bdellonyssus sylviarum. Like *B. bursa, B. sylviarum* feeds readily upon young chicks either in the partial light of a rearing chamber or in total darkness. It also

resembles *bursa* in that the initial meals are usually incomplete. The preferred feeding areas on the chick are the head and vent regions. Blood ingested by *B. sylviarum* becomes black several hours earlier than in *B. bursa* and *D. gallinae*.

In a highly populated *B. sylviarum* colony, the litter as well as the chick is covered with mites, and clusters of mixed stages rest on topmost parts of the rearing chamber. When the mite population is low, however, most of the specimens will be found on the chick. This species does not crawl as fast or as aimlessly as *B. bursa* when disturbed. Instead, it seems to adjust rather rapidly to the conditions and becomes quiet until excited by another disturbance.

Almost all eggs are laid upon the chick except when the mite population in the colony is extremely large. Usually the vent and head of the chick present a dirty appearance, caused by a mixture of eggs, moult skins, excreta, and mites.

Dermanyssus gallinae. *D. gallinae* feeds best at night or in a darkened room but will feed during the day in the half-light of the rearing chamber if starved a few days. This species usually engorges completely at the first opportunity and in this respect differs from *B. bursa* and *B. sylviarum*.

TABLE 1.—*Average measurements (length by width) of various stages of* Bdellonyssus sylviarum, B. bursa *and* Dermanyssus gallinae, *expressed in millimeters.*

	B. sylviarum	*B. bursa*	*D. gallinae*
Egg	0.31 by 0.19 (25)*	0.30 by 0.20 (15)	0.39 by 0.26 (14)
Larva	0.31 by 0.18 (11)	0.30 by 0.20 (11)	0.39 by 0.24 (22)
Unfed protonymph	0.30 by 0.18 (25)	0.30 by 0.18 (25)	0.40 by 0.24 (25)
Engorged protonymph	0.46 by 0.24 (5)	0.47 by 0.23 (12)	0.55 by 0.32 (14)
Unfed deutonymph	0.53 by 0.27 (4)	0.58 by 0.27 (10)	0.59 by 0.33 (22)
Engorged deutonymph	..**	..**	0.75 by 0.39 (25)
Unfed female	0.59 by 0.36 (24)	0.70 by 0.45 (27)	0.92 by 0.52 (26)
Engorged female	0.76 by 0.49 (16)	0.84 by 0.49 (31)	1.0 by 0.64 (15)

* Figure in parenthesis indicates number of specimens measured from which average dimensions were calculated.

** The deutonymph is a non-feeding stage in *B. sylviarum* and *B. bursa*.

The engorged mites immediately seek hiding places. Clusters of them may be found, bedbug-like, in crevices, such as behind the chick feeder and watering tray. They remain in hiding about three days and lay their eggs at the site of clustering. As soon as oviposition is completed, they rest quietly on grass stems and in crevices, ready to feed again as soon as a host chick is made available to them. When disturbed, they crawl rapidly for a time on the grass and up the sides of the rearing chamber.

Measurements and weights. Measurements and weights of different stages of unfed and fully engorged *B. sylviarum, B. bursa,* and *D. gallinae* were taken to compare sizes and to determine amounts of blood ingested. Table 1 gives the average lengths and widths of specimens.

No growth occurs in any of the three species prior to feeding in the protonymph stage. *D. gallinae* in all stages is the largest of the three species. The protonymphs of *B. bursa* and *B. sylviarum* are about equal in size, although *B. bursa* is the larger in the adult stage.

The average weights of the various feeding stages are given in Table 2. Sub-

tracting average weights of unfed protonymphs from those of fully engorged ones reveals an average of 0.025 and 0.023 mg. of blood ingested per specimen by *B. bursa* and *D. gallinae,* respectively. The number of engorged *B. sylviarum* protonymphs obtained was insufficient for weighing. The deutonymph of *D. gallinae* ingested 0.052 mg.

The average weights of both unfed and engorged adult female *B. bursa* were nearly twice those of similar specimens of *B. sylviarum,* while those of *D. gallinae* were three to four times as great. The average fully engorged *B. sylviarum* adult female contained 0.041 mg. of blood; *B. bursa,* 0.077 mg.; and *D. gallinae,* 0.204 mg. Adult females of *B. sylviarum* ingested 1.6 times their body weight of blood; *B. bursa,* 1.8 times; and *D. gallinae,* 2.7 times.

Life cycles. B. sylviarum, B. bursa, and *D. gallinae* have the same stages represented in their life cycles. *D. gallinae* differs, however, in that the deutonymph takes blood like the protonymph, whereas in both *B. sylviarum* and *B. bursa* the deutonymph moults to adult stage without feeding.

Fully engorged females of each species were isolated in small glass tubes and observed periodically. The time required for egg laying, egg hatching, and moulting

TABLE 2.—*Average weights of unfed and fully engorged specimens of various feeding stages of* Bdellonyssus sylviarum, B. bursa *and* Dermanyssus gallinae, *expressed in milligrams.*

	B. sylviarum	*B. bursa*	*D. gallinae*
Unfed protonymph	0.004 (529)*	0.005 (375)	0.010 (489)
Engorged protonymph	**	0.030 (33)	0.033 (351)
Unfed deutonymph	..***	..***	0.024 (192)
Engorged deutonymph	..***	..***	0.076 (73)
Unfed female	0.025 (234)	0.043 (102)	0.076 (109)
Engorged female	0.066 (51)	0.120 (35)	0.280 (72)

* Figure in parenthesis indicates number of specimens weighed from which average weights were calculated.
** Number of engorged protonymphs of *B. sylviarum* insufficient for weighing.
*** Weights not taken as deutonymph is a non-feeding stage in *B. sylviarum* and *B. bursa.*

of the non-feeding larvae to protonymphs were recorded. The protonymphs, in turn, were fed upon chicks and fully engorged specimens isolated for observations. In the case of *D. gallinae,* in which the deutonymph takes blood, that stage was also permitted to engorge.

Bdellonyssus bursa. Thirty-eight of 40 fully engorged females laid 72 eggs within 22 hours. Within 46 hours a total of 95 eggs had been deposited. Some specimens produced only 1 egg, the majority 2 to 5, and the greatest number from a single female was 7.

Between 1.5 to 2 days following oviposition all eggs had hatched (except 5 which were nonviable), giving rise to quiescent, six-legged larvae which moved no more than a few egg-lengths away from the shell. These moulted in less than a day to become very active, eight-legged protonymphs. All except 3 of the progeny had reached the protonymph stage within 77 hours of the feeding by the 40 females. At this time the parent females were again active.

The protonymph of *B. bursa* usually requires at least 2 feedings (one or more partial meals and a final complete engorgement) in order to moult. Although a small percentage of the specimens completed these feedings within 24 hours, 36

to 48 hours were usually required. Moulting to the deutonymph occurs from a day to a day and a half after the complete engorgement. The deutonymph moults without feeding to the adult stage in less than another day. The entire cycle from the initial feeding of adult female to a second generation of adults can be accomplished in as few as 5 to 7 days, although more time will be required if delays occur in protonymphal feedings.

Like protonymphs, only a small proportion of adults engorged fully as soon as an opportunity was presented. The following experiment was conducted to investigate this phenomenon of partial feeding.

Females were reared from the protonymph stage to make certain they had never had a blood meal as an adult. About 300 were placed upon each of 5 immobilized one-day-old chicks, each chick in a separate glass chamber (labeled A-E) set in a tray of water as a moat. The room was then darkened. After six hours, chamber A and its moat tray were quietly removed from the room and all mites recovered, either from the chick, the glass chamber, or the water of the moat. The chick was killed and rinsed in alcohol to facilitate finding the mites. The numbers of non-feeders, partial feeders, and complete feeders were recorded. At 22 hours, a similar procedure was used for chamber B; at 30 hours, for chamber C; at 46

TABLE 3.—*Changing ratio of partially engorged to fully engorged young adult females of* Bdellonssus bursa *in respect to undisturbed time upon one-day-old chicks*

Chick no.	Hrs. mites with chick	No. not feeding	No. partially engorged	No. completely engorged	Percent feeders completely engorged
A	6	6	339	6	1.7
B	22	2	303	9	2.9
C	30	0	319	30	8.6
D	46	2	204	70	26.0
E	55	0	154	110	42.0

hours, for chamber D; and at 55 hours, for chamber E. Thus, records were obtained on the status of feeding after undisturbed 6-hour, 22-hour, 30-hour, 46-hour, and 55-hour periods. The results, showing the changing ratios of partial feeders to complete feeders, are given in Table 3.

These data reveal that practically all specimens had fed to some degree within 6 hours. At that time, however, only 1.7 percent of the feeders were fully engorged. At 22 hours, 2.9 percent had engorged fully; at 30 hours, 8.6 percent; at 46 hours, 26 percent; and at 55 hours, 42 percent. These figures indicate that as time passed, more and more of the partially engorged specimens refed and took additional blood. Therefore, except for a small percentage of specimens, at least 2 feedings were necessary for full engorgement.

Bdellonyssus sylviarum. Thirty-four fully engorged females were isolated and observed individually. Within 24 hours, 31 of the 34 had laid 42 eggs. Oviposition was completed within 48 hours, with a total production of 77 eggs. The number of eggs per specimen ranged from 1 to 5, with 2 and 3 being the most frequently occurring numbers. In less than a day they hatched to quiescent, six-legged larvae, apparently identical with those of *B. bursa.* These moulted in less than a day to become very active, eight-legged protonymphs. Between 68 and 89 hours were required from the adult female blood meal to the time all eggs had produced protonymphs.

Protonymphs of *B. sylviarum,* like those of *B. bursa,* usually required at least 2 feedings and 1 to 2 days before full engorgement was reached, although the actual feeding time for a single meal was quite brief. The adult stage was attained within 2 days after full engorgement of the protonymph. From protonymph to deutonymph required about one to one and one-half days of this time, while less than a day elapsed from deutonymph to adult. The complete cycle from the blood meal of the adult female to a second generation of adults was accomplished in as few as 5 to 7 days. Delays in protonymphal feeding usually extended this period, however, for without a full engorgement, moulting to the non-feeding, deutonymph stage and thence to adult was not accomplished.

Dermanyssus gallinae. Within 24 hours of engorgement, 19 of 29 females had laid 31 eggs, and within 48 hours, 28 had laid a total of 109 eggs. By 72 hours the 29 specimens had completed their oviposition with a total of 140 eggs. Thus, *D. gallinae* required a full day longer to complete egg laying than did *B. sylviarum* or *B. bursa.* The number of eggs per specimen ranged from 1 to 9, more frequently 4 to 7.

TABLE 4.—*A comparison of mite feedings upon mouse, rabbit, man and chick.*

Mite species	Host	No. mites on host	Percent feeding	Percent females laying eggs	Average no.* eggs per female	Percent hatch
B. sylviarum	mouse	125	94	20	1.96	94
	rabbit	185	97	15	1.70	80
	man	190	0	..	..	..
	chick	140	96	25	2.27	95
B. bursa	mouse	192	95	1.6	1.66	80
	rabbit	180	96	2.3	2.5	100
	man	195	0	..	..	..
	chick	175	98	15	2.16	96
D. gallinae	mouse	135	81	29	2.1	65
	rabbit	182	67	16	2.0	45
	man	195	5	10	1.0	0
	chick	130	96	59	3.3	82

* Only those laying eggs included in calculations.

Within 5 days of engorgement, 80 percent of the eggs had hatched (the remainder were nonviable) and the larvae had moulted to protonymphs. Of this time, between one and two days were required for egg hatching and another day for moulting of the larvae.

The majority of *D. gallinae* protonymphs, unlike those of the other two species, engorged completely at a single blood meal. In a little over a day they moulted to form deutonymphs. These engorged readily and reached the adult stage in less than two days. Thus a cycle may be completed in 8 to 9 days from the time of engorgement of a female until a new generation of adults is produced.

Animal Host Studies. Various authors have reported bird mites to feed upon several vertebrate hosts. Wisseman and Sulkin (1947) list animals *D. gallinae* have been reported to parasitize, including 8 species of birds as well as rats, mice, and man. Cameron (1938) lists *B. sylviarum* from a lemming in Canada, and cites references to attacks upon man by *B. bursa.* Riley and Johannsen (1938) report that both *B. sylviarum* and *B. bursa* cause irritation of the skin of man.

To compare feedings of *D. gallinae, B. bursa,* and *B. sylviarum* upon various hosts, hungry adult mites from stock colonies were placed on the skin of mouse, rabbit, chick, and man in small cardboard cells. All were left overnight to feed

except those on man, which were left 3 hours in the dark on the inner surface of the arm. After the feedings, the number of mites taking blood in each lot was recorded. Engorged specimens were isolated and observed for number of eggs laid and percentage of eggs hatching. No evidence of toxicity of the abnormal host blood to the mites was noted. The results are shown in Table 4.

About the same proportion of *B. sylviarum* fed upon mouse and rabbit as upon the chick. None fed upon man under the conditions imposed. A somewhat greater percentage of mites feeding upon chicks engorged sufficiently to induce oviposition and laid a greater average number of eggs per clutch than did that which fed upon the mouse or rabbit.

As with *B. sylviarum,* about the same proportion of *B. bursa* fed upon mouse and rabbit as upon the chick but failed to feed on man. A considerably greater proportion of the chick feeders laid eggs, however, than did the mouse and rabbit feeders. The number of eggs laid per female appeared to be nearly equal in the chick and rabbit series, but fewer in the mouse series. The hatch also appeared poorer on mouse blood.

In the *D. gallinae* tests, nearly as good feedings were obtained on a mouse as on a chick but the percentage of mites which subsequently laid eggs was only about half as great. The average number of eggs laid per specimen was also less as a result of mouse feeding and the hatch was poorer. Rabbits appeared to be poorer hosts than mice, as only 67 percent of the mites placed on the rabbit fed, of which only 16 percent laid eggs. The egg viability was lower as well. Very few *D. gallinae* could be induced to feed on man, and of the few eggs laid as a result of such feeding, none hatched.

SUMMARY

Observations were made on the behavior of *Bdellonyssus bursa, B. sylviarum,* and *Dermanyssus gallinae* in laboratory colonies. Their feeding habits, life cycles, weights and measurements of various stages, and volumes of blood ingested were compared.

Under experimental conditions, all three species fed readily upon mice and rabbits as well as chickens, but only a few *D. gallinae* could be induced to feed upon man.

Literature Cited

Cameron, D. 1938 The northern fowl mite (*Liponyssus sylviarum* C. & F., 1877). Investigations at MacDonald College, Que., with a summary of previous work. Canad. J. Research **16** Sect. D: 230–254.

Chamberlain, R. W. and Sikes, R. K. 1950 Laboratory rearing methods for three common species of bird mites. J. Parasit. **36:** 461–465.

Riley, W. A. and Johannsen, O. A. 1938 Medical Entomology, Second Edition, 483 pp. McGraw-Hill Book Co., Inc.

Wisseman, C. L. Jr. and Sulkin, S. E. 1947 Observations on the laboratory care, life cycle, and hosts of the chicken mite, *Dermanyssus gallinae.* Am. J. Trop. Med. **27:** 463–469.

Wood, H. P. 1917 The chicken mite: Its life history and habits. Dept. Bull. No. 553, U. S. Dept. Agric., 14 pp.

————1920 Tropical fowl mite in the United States, with notes on life history and control, Dept. Circular No. 79, U. S. Dept. Agric., 8 pp.

RESEARCH NOTES

OCCURRENCE OF LARVAE OF *TAENIA TAENIAEFORMIS* (BATSCH, 1786) IN THE AMERICAN RABBIT, *LEPUS AMERICANUS*

Through the kind offices of Dr. E. E. I. Hancock, Director, Animal and Poultry Services, of the Nova Scotia Department of Agriculture, larval tapeworm material taken from the back muscles of a rabbit, *Lepus americanus,* was sent to us for examination.

The specimens are larvae of *Taenia taeniaeformis* (Batsch, 1786) showing the typical strobilocercus of this larva. The scolex bears 50 to 60 hooks arranged in a double crown. The large hooks measure 380 to 392 microns with a base of 224 to 245 microns. The small hooks are 225 to 240 microns long with a base of 136 to 144 microns. The shape of the hooks is characteristic of the *taeniaeformis-laticollis-parva* group of Taenias. These features agree with the classical descriptions of Pintò (Campo, Rio de Janeiro, **7**: 26–29, 1936) and Joyeux and Baer (Faune de France Féd. Franç. Soc. Sc. Nat., 613 pp., 1936).

The larva of *Taenia taeniaeformis,* also known as *Cysticercus fasciolaris* Rudolphi, 1808, is a cosmopolitan parasite commonly found in rodents—rats, mice, muskrats, squirrels, etc.—the normal location being the liver and less frequently, the body cavity. The first and only occurrence of *C. fasciolaris* in a leporid is recorded by Joyeux, Senevet and Gros (Arch. Inst. Pasteur, Algérie, **16**: 26–30, 1936). These authors found the larvae in the liver of the domestic rabbit, *Oryctolagus cuniculus,* from Algiers. Schiller (J. Parasit., **35** (6, sect. 2) : 37–38) carrying out experimental infections with cysticerci of *Taenia taeniaeformis,* reports that he was unable to infect rabbits.

As far as can be ascertained, this is the first record of *Taenia taeniaeformis* larvae occurring in *Lepus americanus,* and the first record of this larva from a leporid from North America.—June Mahon, *Institute of Parasitology, Macdonald College, Prov. Que., Canada.*

A TECHNIQUE FOR HATCHING MIRACIDIA IN DILUTE FORMALIN

Although the life cycle of *Urotrema scabridum* (Urotrematidae), an intestinal parasite of bats and muskrats, is unknown, it appears likely that the miracidia normally hatch only after being ingested by a snail. The small egg (18 by 9 microns) contains a fully developed miracidium when deposited. Hatching could not be induced when eggs were left up to 7 days in distilled water, tap water, or 0.85% saline at room temperature. Storage in the refrigerator in these fluids up to 10 days with subsequent exposure to room temperature, also failed to produce hatching. Formalin (3%) was added to some of the preparations to control bacterial growth.

Later when preparations containing formalin were examined a few miracidia had hatched When living adult flukes were macerated in 3% formalin hatching occurred in 1 to 2 minutes but the miracidia were killed immediately. Testing of a series of dilutions of formalin gave an "end point" (no hatching) at 0.05%. Maximum hatching and survival of the miracidia resulted when adult flukes were washed in 0.85% saline and the uterus dissected out in a small drop of 0.075% formalin in 0.85% saline. In this solution hatching began in about 1 minute. Before hatching the miracidium began slight squirming motions and the cilia became active. In covered or uncovered preparations the miracidia had limited motility although the ciliary action was quite vigorous. No miracidium lived longer than 55 seconds, with the majority dying in 30 seconds.

Application of this technique to members of other families met with varying success. With *Limatulum gastroides* (Lecithodendriidae) hatching occurred at 0.05%. Miracidia of *Haematoloechus medioplexus* (Plagiorchiidae) did not hatch at concentrations up to 3%. For *Brachylaemus virginiana* (Brachylaemidae) some hatching was observed at 3%, but none at lower concentrations.—F. G. Tromba, *Animal Disease and Parasite Research Branch, United States Department of Agriculture, Beltsville, Maryland.*

SOME OBSERVATIONS ON THE LUNGWORM OF THE CAT

Aelurostrongylus abstrusus, the lungworm of the domestic cat, has been reported from several localities in the eastern and southern parts of the United States (W. S. Bailey, 1952, Auburn Vet. **9**: 36–38), but no records exist for the Pacific Northwest states. Five cats in the Seattle area, examined by W. H. Suddeth, D. V. M., for respiratory or systemic disease, have been found to release larvae characteristic for this species. Two of the three cats which died were autopsied, disclosing lung pathology typical of verminous pneumonitis. Dissection of the lung tissue revealed several adult nematodes, including two intact males, allowing accurate confirmation of this species. Two of the cats survived, following treatment to be described elsewhere.

Larvae in feces placed upon non-nutrient agar at room temperature remained alive up to 3 weeks. Activity rapidly declined after the first 10 days, but for several days thereafter, flooding with water or other manipulation stimulated movement. No sign of moulting was seen. More than 100 active larvae were fed to each of a dozen mice. Examination of these mice after intervals of 2 to 10 weeks failed to reveal any larval nematodes. This failure to infect mice agrees with the observations of Baudet (1933, Tijdsch. v. Diergeneesk. **60**: 982–985), and of Hobmaier and Hobmaier (1935, Proc. Soc. Exp. Biol. and Med. **32**: 1641–1647), and disagrees with the report of Cameron (1927, J. Helm. **5**: 55–66).—Paul V. Gustafson, *Dept. of Microbiology, University of Washington, Seattle.*

CREEPING ERUPTION ACQUIRED IN INDIANA

Creeping eruption or larva migrans is a parasitic dermatosis which in the United States is usually caused by filariform larvae of the canine or feline strains of *Ancylostoma braziliense.* The organism burrows a serpiginous tunnel in the stratum germinativum giving rise to a corresponding itching lesion of the skin which is usually vesicular in character. (Craig and Faust, Clinical Parasitology, 5th Edition. Rubin: 1944—see Craig and Faust p. 353. Wilson, J. T., 1944; Jour. Florida Med. Assn. **30**, 425–426.)

This clinical condition is very commonly observed in the southeastern United States but only occasionally is it seen in other parts of the country where it is usually brought in by recent arrivals from Florida.

A search of the literature failed to disclose any cases where the infection was acquired in Indiana. However, recently, I had occasion to treat for this condition a patient who is noteworthy because he apparently represents the first instance where the source of infection was found to be not only local but of such nature as to warrant close attention lest other similar cases be overlooked.

This was a 17 year old boy who presented himself with an itching dermatosis of the right foot consisting of multiple vesicular serpiginous lesions of three weeks' duration. Daily observation showed that the lesions were progressing in linear fashion at a rate of a few centimeters a day. The foot was edematous and somewhat cyanotic. Diagnosis of creeping eruption was made and the patient hospitalized for further study and treatment. The history revealed that he had not been outside the state of Indiana for some time, but approximately one week before the onset of symptoms, he had been employed in a grocery cleaning the basement that was flooded by a backed-up sewer. He had worn boots but his feet got wet nevertheless.

On admission the temperature was 98°. Blood count as follows: RBC—5,600,000; Hb.—16 grams; WBC—10,100; Eosinophiles—6%; Segmented neutrophiles—74%; Lymphocytes—17%; Monocytes—3%. Mazzini, X-ray of the foot and urinalysis were negative.

The eosinophilia supported the diagnosis of creeping eruption. A biopsy was considered unnecessary and even contraindicated in the presence of secondary infection.

Treatment consisted of daily freezing of the lesions with ethyl chloride spray and intramuscular administration of Fuadin (Antimony biscatechol disulphonate of sodium) as recommended by Rubin and Wilson according to the following dosage schedule: Fuadin intramuscularly first day 2.0 cc; second day 3.5 cc; third day 5.0 cc; fourth day 5.0 cc; fifth day 5.0 cc for a total of 20.5 cc within five days.

The patient made an uneventful recovery and was discharged after one week's hospitalization. On reexamination ten days later there was no recurrence of the lesions and only minimal residual edema of the foot. The patient was discharged and returned to work.

This case is remarkable because it seems the first one to be acquired in Indiana and in a manner which may recur in other instances. Creeping eruption should therefore be watched for and considered in obscure dermatoses of the feet.—Alfred J. Niedermayer, *Evansville, Indiana.*

A NEW HAEMOGREGARINE REPORTED FROM THE SPOTTED SQUETEAGUE, *CYNOSCION NEBULOSUS,* IN FLORIDA

Haemogregarines have been known to occur in the blood of fishes since they were first reported by Laveran and Mesnil (1901: C. R. Acad. Sci. Paris **133**: 572–577) from France. To date none has been reported before from the United States, and Fantham, Porter and Richardson (1942: Parasitol. **34**: 199–226) have recorded the only ones yet to be found elsewhere in North America, in Eastern Canada.

The author has examined several hundred smears, taken during the winter of 1953–'54, of the heart blood of a number of species of marine fishes from Lemon Bay at Englewood, Fla. In the blood of the spotted squeteague or sea trout (*Cynoscion nebulosus*), an important com-

mercial fish variety in the state, a haemogregarine, probably actually a schizohaemogregarine, was found.

In the typical fish haemogregarine life history, asexual division occurs in the internal organs or bone marrow. This schizogony takes place repeatedly and large merozoites are formed. Each merozoite then penetrates an erythrocyte of the circulating blood and grows into a gametocyte. In the schizohaemogregarines, the schizogony divisions take place in the cells of the circulatory blood. By several divisions a number of merozoites are formed, usually in the red corpuscles. Neumann (1909: Zeitschr. Hyg. Infektionskr. **64:** 1–112) has described 16 merozoites formed in a single red corpuscle of the parasite, *Haemogregarina polypartita,* found in the *Gobius paganellus* of Europe. This is the largest number of merozoites yet recorded in any single erythrocyte. Laird (1953: Trans. Roy. Soc. New Zealand **81:** 79–96) described the merozoite formation of *H. bigemina* for the first time and reported it as occurring not in erythrocytes, but in leucocytes.

The parasite found by me in a Giemsa-stained smear of heart blood of *Cynoscion nebulosus* is shown in the accompanying figure, and was drawn by means of a camera lucida. The parasitized cell is about 44 microns in length by 20 microns at its average width. There is a large, light pink-staining nucleus at one end, and its cytoplasm stains a pale blue and shows no granular structure. At the opposite end to the nucleus of the host cell are 17 merozoite bodies. Each one has a dull red-staining nucleus at one pointed end, and tapers at the opposite end to elongated, blue-staining cytoplasm. These merozoites measure 9–10 microns in length by 1–2 microns in breadth, and are arranged roughly in two rows. No other recognizable stages were seen, although smears of spleen and kidney were made and examined.

It seems clear that the form found in *Cynoscion nebulosus* differs from those species already described in the literature. It differs from the regular haemogregarines by not having schizogony take place in erythrocytes, although the number, 17, might possibly be an aberrant division that would normally produce 16 merozoites. Its schizogony takes place in leucocytes, as in the schizohaemogregarine, *H. bigemina,* but its 17 merozoites separate it from the maximum of 10 found in the latter species. The size of the host cell and merozoites, themselves, are also both larger than those found in *H. bigemina.* Further collections and examinations from this fish are planned, and it is hoped that other stages of the parasite's life history may be found.

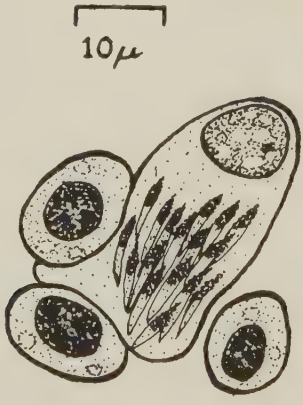


FIG. 1. Merozoites of the haemogregarine found in the leucocytes of *Cynoscion nebulosus.*

The author wishes to extend thanks to Dr. Ross Nigrelli of the Aquarium of the N. Y. Zoological Society for the aid and encouragement he has given her. Thanks are also due Mr. Stuart Anderson, owner of the Lemon Bay Fisheries of Englewood, Fla., and Mr. Laurence Hooker of Englewood, Fla., for their kind cooperation in obtaining the fresh fish specimens and in providing facilities for making blood smears as they were brought in.—DOROTHY CHAPMAN SAUNDERS, *Department of Biology, University of Florida, Gainesville, Florida.*

AN ANOMALOUS *ANOPLOCEPHALA PERFOLIATA,* A TAPEWORM OF THE HORSE

According to Clapham (1939, J. Helminth, **17:** 163–176) and Kuntz (1948, Proc. Helm. Soc. Wash. **15:** 73–77) abnormalities in the development of cestodes are not uncommon. The majority of the anomalies recorded have been polyradiate forms in the TAENIIDAE. Relatively few such cases have been reported in the ANOPLOCEPHALIDAE, and as far as the authors could ascertain only two anomalous specimens of *Anoplocephala perfoliata* have been previously

described (Neumann, 1890, Rev. Vét. Toulouse, **47:** 478–486. and Meggitt, 1916, Parasitology, **8:** 379–389). The present communication records the finding of a third triradiate *A. perfoliata,* apparently the first to be reported from this hemisphere.

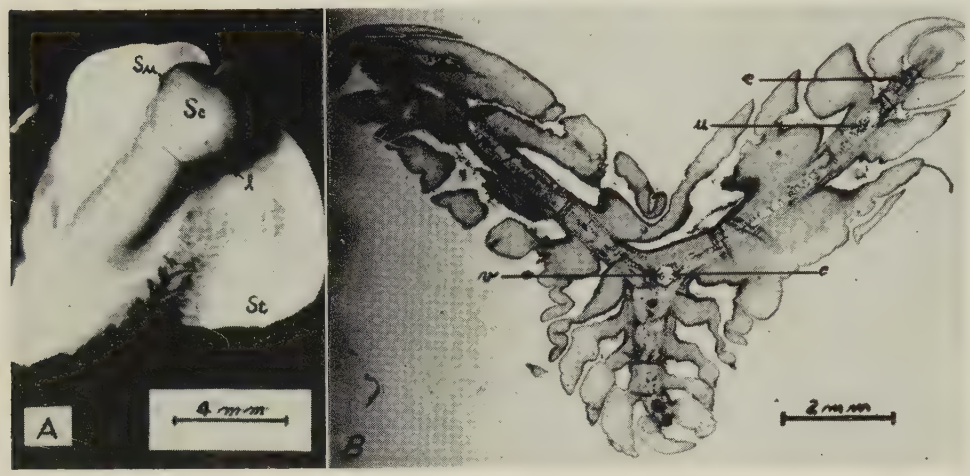


Figure A. The *in toto* triradiate specimen viewed from the anterior end.
Figure B. Cross-section of a terminal segment.
Abbreviations used.—c central space, e excretory vessel, l lappet, Sc scolex, St strobila, Su sucker, u uterus, v seminal vesicle.

This anomalous specimen was encountered in a Thoroughbred yearling which harbored 5 additional normal tapeworms, and was the only one observed among 755 specimens of *A. perfoliata* collected from 15 naturally infected horses from the central Kentucky region during the past 2 years.

The general appearance of the worm (viewed from the anterior end) is shown in Figure A, and is similar to those reported by Neumann (1890) and Meggitt (1916). The 6 suckers and 6 lappets were aranged on the scolex so that 2 of each occurred in a position corresponding with each of the 3 branches of the strobila. An examination of the cross-section presented in Figure B revealed the internal structural arrangement to be essentially the same as the detailed description given by Meggitt (1916). This investigation is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director of the Station.—J. H. Drudge and S. E. Leland, Jr., *University of Kentucky.*

SEROLOGICAL SURVEY DATA ON THE PREVALENCE OF TOXOPLASMOSIS IN THE JEWISH POPULATION OF NEW YORK

The recent report by Farrell, Docton, Chamberlain, and Cole (Am. J. Vet. Res. 1952, **13:** 181–185) of the finding of toxoplasmosis in swine, naturally led to the conjecture that pork might serve as a source of infection for human beings. The least expensive way of testing such an hypothesis appeared to be a serological survey of orthodox Jews in the older age groups. In the general population, 45 to 65 percent of individuals in the age groups of 45 years and over show positive skin tests or dye tests for toxoplasmosis (Feldman, Am. J. Trop. Med. Hyg. 1952, **2:** 420–428). The examination of even a small group of aged individuals who customarily do not eat pork should supply a significantly lower result if pork does serve as the source of human infection. Therefore, serum specimens from 62 orthodox Jewish patients at the Jewish Hospital of Brooklyn have been tested by the dye test of Sabin and Feldman (Science, 1948, **108:** 660–663). All of these individuals were over the age of 45 years; six were between 45 and 47 years of age, 13 were in the sixth decade and 20 in the seventh decade of life, and the rest were over 70 years old. Thirty were males and 32 females. All of these individuals denied eating pork; all but 18 claimed strict observance of the Mosaic law and the others stated that while they did not always eat kosher meats (i.e. meats prepared under kosher supervision) they shunned pork. Thirty, or 48.4 percent, of these individuals showed dye test titers generally considered significant, 1:16 or higher; of these, two were 1:32, four were 1:64, one 1:128, and two 1:256. Only six persons showed no dye test antibodies at all, giving a completely negative reaction. Twenty-six individuals showed low titers of 1:1 to 1:8. If the dye test is taken to be specific evidence of past infection with *Toxoplasma,* as it generally is considered

because of the absence of information on cross-reactions, the data presented here must be accepted as strong evidence against the idea that *Toxoplasma* infections in humans are usually acquired by the ingestion of pork.—Leon Jacobs, M. Katherine Cook (*Laboratory of Tropical Diseases, National Institutes of Health, Bethesda, Maryland*), and Edith Neumann (*Jewish Hospital of Brooklyn*).

THE INFLUENCE OF SEX ON MOUSE PINWORM INFECTION

Aspiculuris tetraptera, an oxyurid of mice, has been used by various investigators for chemotherapeutic screening purposes (Hsieh, K. N., 1952, Am. Jour. Hyg. **56**: 287–293; Wells, H. S., 1951, Jour. Inf. Dis. **89**: 190–192; Thompson, P. E. and Reinertson, J. W., 1952, Exper. Parasitol. **1**: 384–391.) Experimental infections made by me were subject to wide variations, and an investigation of the host-parasite relationship seemed advisable. A series of preliminary experiments in which mice of varying ages were infected, showed an apparent diversity in size of infection which was related to the sex of the host. These age groups varied from 2 to 6 weeks. The total number of mice used was 85, 37 females, and 48 males. The average results for all age groups showed that the males harbored 102.5 worms/mouse, and the females 29.5 worms/mouse. In order to determine the validity of these observations, an investigation was undertaken under carefully controlled conditions. The animals used consisted of 4 litters of 3-week-old nematode-free white mice. This age group had been found to yield the best infection rate. The mice were separated according to sex at 12 days of age, all females with 2 of the mothers, and all males with the other 2 mothers. The mice were weaned the day before infection. The eggs for infection purposes were obtained from gravid *Aspiculuris* females and were incubated in water for 7 days at 27° C. (Wells, H. S., 1951, Jour. Inf. Dis. **89**: 190–192). The eggs were evenly suspended in water by the use of gum tragacanth, and a dilution count was made. The mice were then given approximately 500 embryonated eggs by oral intubation through a blunt-tipped 18 gauge needle. After use, dilution counts were done on the remaining fluid to be sure that the concentration of eggs remained constant. Twenty-one days later, the mice were sacrificed and a thorough search made of the large intestine for *Aspiculuris*. The worm burdens produced in the male (range 138–343 worms/mouse, ave. 252 worms/mouse) were twice as great as those in the female mice (range 5–222 worms/mouse, ave. 113.8 worms/mouse) as is shown in Table 1. The ranges in both sexes are wide ones, but the male mice showed a more uniform infection than the female mice.

Table 1.—*Worm burdens of male and female mice*

Sex of mice	Number of mice	Number of eggs given per mouse	Average worm burden per mouse	Percent return (infection rate)
Male	19	500 ±	252.0 ± (range 138–343)	48.7
Female	18	500 ±	113.8 ± (range 5–222)	22.0

These data show a statistically significant inhibition of infection in female mice and may account for the irregular size of infections in groups of mice of mixed sex.—Allen W. Mathies, *School of Public Health, College of Physicians and Surgeons, Columbia University, New York, N. Y.*

A SURVEY OF MUSKRAT HELMINTHS IN ILLINOIS

Through the cooperation of the Illinois State Department of Conservation, 250 muskrats (*Ondatra z. zibethica*) were examined for helminths during the trapping season of 1951–52. Approximately one-half of these animals were collected from 5 of the northern zone counties (Kankakee, Livingston, Marshall, Ogle, and Stephenson) while the remainder came from four of the central zone counties (Champaign, Logan, McLean, and Vermillion).

One or more species of helminths occurred in 55.4% of the animals examined; two or more species in 11.7%. Trematodes occurred in 43.6% of the animals examined while nematodes and cestodes occurred in 6.3% and 1.9% respectively. Both sexes were parasitized to the same extent, helminths being recovered from 45.1% of the males and 47.1% of the females.

The incidence of infection of animals collected in the northern zone was 56.9% with a mean worm burden of 19.8 ± 4.0. In the central zone, 54.5% of the animals collected were infected with a mean worm burden of 11.8 ± 1.6. These differences are not statistically significant. When data were analyzed on the basis of collecting areas, a significant difference of 40.8 ± 9.6% was found between the 90.3% infection in muskrats collected from Fairmount Quarry, Vermillion, Co., and the infection rate of 49.5 ± 3.7% for the other areas. The worm burden (20.5 ± 11.1) per infected animal in this area does not differ significantly from the mean number of worms

(13.5 ± 3.3) recovered from animals examined from other areas. The quarry area had not been trapped for the previous two years and, based on trapper reports, the muskrat population in the area was at a relatively higher density. The high degree of parasitism cannot necessarily be attributed to the size of the muskrat population since the effects of the relative abundance of intermediate hosts, difference in food habits, and other epidemiological factors are not known.

The Fairmount Quarry is also of interest because this is the only area in which muskrats were found infected with *Pseudodiscus zibethicus* (Barker and East, 1915) Fukui, 1929. This parasite was recovered from 67.7% of the animals; the average worm burden was 4.8 ± 1.3. Examination of muskrats taken from collecting areas within a 20 mile radius of the Quarry failed to disclose a single infection with this parasite although some of these areas were ecologically similar to the Quarry. Since the life cycle of *P. zibethicus* is unknown, an evaluation of factors responsible for the distribution of this trematode within the area studied cannot be made.

The species of helminths found and their incidence in the muskrats examined are as follows:

Species	% of animals infected	Species	% of animals infected
Trematoda		Nematoda	
Echinostomum revolutum	32.4	*Nematospiroides longispiculatus*	4.5
Pseudodiscus zibethicus	9.5	*Ascaris lumbricoides*	2.2
Quinqueserialis quinqueserialis	6.3	*Trichuris opaca*	1.3
Notocotylus sp.	4.5	Cestoda	
Amphimerus pseudofelineus	1.8	Cysticercus of *Taenia taeniaeformis*	2.2
Plagiorchis proximus	1.3	*Hymenolepis evaginata*	0.4
Fibricola cratera	0.4		
Nudacotyle novicia	0.4		
Schistosomatium douthitti	0.4		

James H. Gilford.—Division of Medical Entomology, School of Hygiene and Public Health, The Johns Hopkins University.

THE HEMOFLAGELLATE, *CRYPTOBIA SALMOSITICA,* IN OREGON SALMON

Cryptobia salmositica Katz were observed in the blood of a silver salmon fingerling, *Oncorhynchus kisutch* (Walbaum), collected from Beaver Creek, Lincoln County, Oregon, on February 22, 1954. This is the first known record of this hemoflagellate in fish taken in the state of Oregon. Beaver Creek has its source in the foothills of the Coast Range and flows directly into the Pacific Ocean approximately 10 miles south of Newport, Oregon.

Large numbers of *Cryptobia* were found in the blood of the largest (112 mm.) fish in the collection. Five other fingerlings of the February 22 collection were held in aquaria and were sacrificed on April 14, 1954. The bloods of these fish were negative.

Three additional silver salmon fingerlings collected from Beaver Creek on April 22, 1954 were examined; two fish of 75 and 83 mm. total length were positive; the third of 106 mm. was negative.

C. salmositica (1951, J. Parasit., **37**: 245–250) was first described from the blood of adult silver salmon taken from Soos Creek, near Auburn, King County, Washington. Soos Creek in a tributary of the Green River which flows into Puget Sound, at Seattle, Washington. These flagellates were later found in fingerling silver salmon taken from Swamp Creek, King County, near Seattle. Harold Wolf of the California Division of Fish and Game (1950, Personal Comm.) found a *Cryptobia* in the blood of wild king salmon, *O. tshawytscha* (Walbaum), taken from the Klamath River, California, and in some advanced fingerlings of the same species held in a display aquarium.

Cryptobia in salmonids have been found only in the late fall, winter, and early spring months. In Soos Creek, Washington fish, Cryptobia were noted only in silver salmon taken from November, 1947 through February, 1948. In fact, every adult fish examined after November 21 was infected with Cryptobia. No Cryptobia were found in silver salmon fingerlings taken in Swamp Creek, Washington, from May through October, 1948; in November, 1948, however, Cryptobia were found in some fingerlings taken from this stream. Ten fish from a collection of silver salmon fingerlings taken in Beaver Creek, Oregon, in October, 1953 and examined February 12, 1954, were negative for Cryptobia. Wolf's letter reporting these hemoflagellates in California salmonids was dated January 18, 1950. Although he did not state definitely the time of these observations he did say they were made "recently."

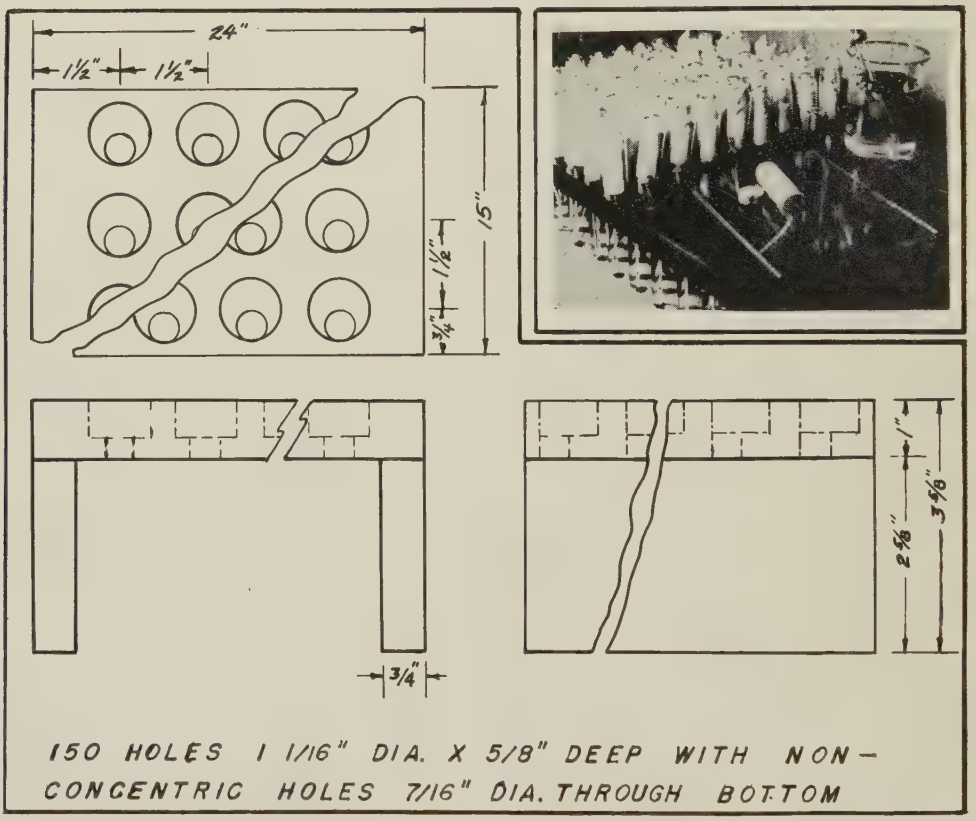
Blood smears of 4 yearling silver salmon fingerlings taken March 1, 1954 (by C. D. Becker) from 4 small tributaries of the Yaquina River were negative for Cryptobia. The Yaquina flows into the ocean at Newport, Oregon, 10 miles north of the mouth of Beaver Creek.

Nothing is yet known of the pathogenicity of this parasite to these commercially important salmonids.—Robert C. Davison, Wilbur Breese, *Department of Fish and Game Management,*

Oregon State College, Corvallis, Oregon and MAX KATZ, *U. S. Public Health Service, Oregon State College, Corvallis, Oregon.*

A CONVENIENT DEVICE FOR EXPOSING MICE TO *SCHISTOSOMA MANSONI* BY TAIL IMMERSION

The advantages of the tail immersion method for the percutaneous exposure of mice to *Schistosoma mansoni* and equipment for carrying out this procedure have been described by Olivier and Stirewalt (1952; J. Parasit. **38:** 19–23). One disadvantage associated with this procedure is that the immobilization of the animals requires the use of adhesive tape and rubber bands or of anaesthesia and rubber bands if one follows the modified method of Luttermoser (1954; J. Parasit. **40:** 130–137). This objection can be circumvented by use of the apparatus illustrated in the figure.



Cercariae are dispensed, as by the above mentioned workers, into test tubes (⅜" × 3") supported by their rims in the wooden immersing stand. Mice are immobilized by inserting them head first into glass holding tubes (1" × 3"), using a notched cork to permit extension of the tail. Ventilation is provided by a ¼" hole at the end of the tube; these tubes can be fabricated readily from tubing or test tubes. The holding tubes are inserted into counter-sunk holes in the stand with the tail of the mouse extending into the cercarial suspension.

The device will accommodate 150 mice of 17 to 21 grams weight range. Mice may be kept in the tubes for several hours although an exposure period of 40 minutes has been found to be adequate for the penetration of 90 to 95 percent of the cercariae. By removing the cercarial suspension after exposure of the mice, the stand serves to hold the animals until they can be handled safely.—DUNCAN MCCARTHY, J. W. REINERTSON AND PAUL E. THOMPSON, *Research Laboratories, Parke, Davis & Company, Detroit, Michigan.*

PRELIMINARY OBSERVATIONS ON AN EXPERIMENTAL TREATMENT FOR DEMODECTIC MANGE IN DOGS

Observations made over the past five years on demodectic mange, caused by the follicle, mite, *Demodex canis* Leydig, indicate that this disease is prevalent in dogs in most of the

urban areas of Alaska. Although a few of the more recently known drugs have some therapeutic value in the treatment of demodectic mange, many cases are either unaffected or continue to recur.

Ayres and Anderson (1932; Arch. Derm. Syph. **25**: 89–98) reported that the medication proving the most successful in the treatment of 12 human cases of facial dermatitis involving *Demodex folliculorum* Simon, was the application of an ointment containing the following:

	gm. or cc.
Betanaphthol	4
Sublimed sulphur	8
Balsam of Peru	30
Petrolatum	30

Insofar as the writers are aware, the efficacy of this preparation as a parasiticidal agent against *D. canis* in the treatment of demodectic mange in dogs has not been investigated heretofore.

The opportunity to make some preliminary observations in this connection was afforded when infected dogs, which had failed to respond to treatment by local veterinary practitioners, were brought to the laboratory of the Animal-borne Disease Branch, Arctic Health Research Center, U. S. Public Health Service. Diagnosis was confirmed at this laboratory on determining the presence of *Demodex canis* by microscopic examination of deep skin scrapings in mineral oil, and medication was undertaken experimentally. Trial applications of the ointment containing the ingredients listed above met with such marked success in the clinical cure of the disease in the animals under investigation that this preparation was used routinely thereafter.

Since the initial observations in 1950, this medication has been used successfully at the Animal-borne Disease laboratory in the cure of 31 cases of demodectic mange. In addition, 25 cases were treated with similar results at the veterinary clinic, Elmendorf Air Force Base, where this medication has been adopted as routine procedure.

The degree of infection varied in these cases from a few small denuded areas around the eyes to rather extensive pustular lesions scattered over the body. The usual procedure followed in administering treatment was to wash the infected area thoroughly with soap and warm water and then to rub the preparation into the skin, covering the lesions as well as a sizeable area surrounding them. Application of the ointment was repeated at weekly intervals for the length of time required to achieve healing which, in this study, ranged from 4 days to 6 weeks, depending in general upon the severity of the infection. Marked improvement was seen in most instances at the end of the first week.

With the exception of 2 cases in which the disease was further complicated by secondary bacterial invasion, none of the infections had progressed to a degree in which there was serious systemic involvement. In order to determine what medicinal effect the test preparation might have on an advanced condition with extremely severe manifestations, a naturally infected mongrel dog, of the large, long-haired variety, was obtained for treatment. This animal was very emaciated and extensive hemorrhagic lesions almost completely covered the body. The external layer of skin was necrotic in many areas and sloughed off on being handled. Blood and serum along with an abundance of mites and purulent material, resulting from secondary invasion by bacteria, exuded from the wounds.

Before medication was undertaken, an attempt was made to infect eleven other dogs with *D. canis* by direct mechanical transfer of deep skin scrapings from this diseased animal to freshly scarified tissue of the experimental animals. These attempts proved unsuccessful since the parasites failed to become established in any of the recipient hosts.

As soon as the procedure of transferring the skin scrapings was completed, the remaining hair was clipped from the infected areas and the diseased animal was bathed in warm water containing a mild detergent. The experimental ointment was then applied generously over the lesions, requiring about 12 ounces to adequately cover the infected tissue. On the fourth day following the initial treatment, 600,000 units of procaine penicillin were administered. Two additional applications of the ointment, similar to the first, were given at intervals of one week. By the end of the second week the dog already showed marked improvement. Spot applications of the ointment were continued thereafter every 7 days, until, at the end of the next 6 weeks, healing of the lesions had taken place and there was no further evidence of demodectic mange mites. Although the dog was still quite thin, there was no recurrence of the infection, and recovery appeared to be complete by the 84th day.

The results of these preliminary tests indicate that the preparation reported by Ayres and Anderson (loc. cit.) has parasiticidal properties against *D. canis* and appears to be of considerable value in external topical medication in the treatment of demodectic mange in dogs. Additional experimental studies in the use of this preparation are needed, however, before its efficacy can be fully evaluated, especially if the life cycle of *D. canis* involves an internal systemic migration in the host animal as suggested by Koutz (1952; Jour. Am. Vet. Med. Assoc. **121**:

470–473).—Everett L. Schiller, *Arctic Health Research Center, U. S. Public Health Service, Anchorage, Alaska, and* James C. McIntyre and Richard E. Shirbroun, *Office of the Wing Veterinarian, Elmendorf Air Force Base, U. S. Air Force, Anchorage, Alaska.*

INFECTION AND DEATH IN THE PIGEON RESULTING FROM THE ORAL IMPLANTATION OF SINGLE INDIVIDUALS OF *TRICHOMONAS GALLINAE*

It has been shown by Stabler (1953, J. Parasit. 39 (4-Sect. 2): **12**; 1954, Exper. Parasit. **3**: 368–402) that when some 5,000–10,000 organisms of the highly virulent Jones' Barn strain of *Trichomonas gallinae* were placed in the mouths of 119 successive *Trichomonas*-free common pigeons (*Columba livia*), 100% infection and 114 deaths (95.8%) resulted. Death occurred at 8.2 days (av.).

The writers were interested in determining whether or not single organisms of this same virulent strain of *Trichomonas* could survive and establish infection when placed in the mouths of clean pigeons. If this were possible, pure line infections could be established, which would be an important tool in the study of trichomoniasis caused by *T. gallinae*.

The trichomonads used were from cultures of the Jones' Barn strain from control #117 in the above series of 119. The cultures were diluted so that minute drops delivered by a micropipette might contain 1, 2, 3, or no trichomonads. The drops were so small that they could be observed in their entirety under a low power objective and 10× ocular. The exact number of trichomonads in each drop could be determined, therefore, without the possibility of error. These minute culture samplings were placed on tiny squares of sheet gelatin cut at about 2 mm. on a side. All squares containing other than one single *T. gallinae* were discarded. Those harboring one flagellate were dropped into the mouths of clean pigeons.

Ten pigeons were thus given a single *T. gallinae* each. Five remained uninfected. Five became positive and all 5 died of typical canker, at 13, 8, 12, 14, and 12 days (11.8 da. av.). The 5 uninfected birds were then given 5,000–10,000 Jones' Barn *T. gallinae* each from control #124. These became positive and all died, 3 dying at 6, 1 at 7, and 1 at 13 days (7.6 da. av.).

It is thus seen that single specimens of *Trichomonas gallinae* can produce infections in clean pigeons, which may lead to their death. Five birds so infected died on an average of 11.8 days after implantation. Five which did not become positive after receiving orally one *T. gallinae* each, died on an average of 7.6 days following oral administration of 5,000–10,000 virulent *T. gallinae* per bird.—Robert M. Stabler and Joanne Tsuneko Kihara, *Colorado College, Colorado Springs.*

TWO HUMAN CASES INFECTED WITH *ECHINOCOCCUS* CYSTS, INDIGENOUS FROM THE UNITED STATES

The following two cases of autochthonous hydatidosis from the United States are of interest and may add to our understanding of the disease in this country.

Case 1. Colored male, 65 years old, born in Mississippi. At the age of 21 he moved to Tennessee and lived the rest of his life at Collierville and Memphis, where he died of heart failure. He had never lived outside of the U.S. At necropsy one firm nodule, two cm. in size, was found on the surface under the capsule in the left lobe of the liver. The tissues inside of the thick lamellar connective tissue cyst wall were very necrotic. Most of the scoleces were disintegrated, and the rostellar hooks, which agreed as to the dimensions and shape of those of *E. granulosus*, were scattered throughout the necrotic substance.

Case 2. Colored girl, 18 years of age, had spent all of her life in the U.S. She was born in Mississippi and at the age of five years moved to Memphis, Tennessee where she lived and met death violently. There was no evidence that she was not in normal health. At necropsy one cyst, 6 by 3.5 by 3 cm. in size was found in the right lobe of the liver. The rostellar hooks were like those in case 1.

These two cases were observed in necropsies made by the Division of Pathology and Bacteriology of the University of Tennessee. It appears that there are more indigenous Hydatid infections in the United States than we have been aware of. Magath (correspondence) informs us that indigenous *Echinococcus* cysts in man have been reported from widely separated states in the U.S. and up to 1949, 33 cases from 17 states have been recorded. A recent report by Franklin and Ward (1953, J. Parasit. **39**: 574) shows infections of *Echinococcus granulosus* in 2 out of 50 dogs examined from Mississippi and they assume that the region in Mississippi from which the dogs were found infected represents an endemic area. Edney (1940, J. Tenn. Acad. Sci. **15**: 395) has also found 2 out of 40 dogs examined with adult *Echinococcus* in Tennessee. Beaver (1954, Vet. Med. **49**: 199) has found dogs infected with the adult of *E. granulosus* in Louisiana.—Peter A. Finck, *Division of Pathology and Bacteriology, and* Arne V. Hunninen, *Division of Preventive Medicine, University of Tennessee, Memphis.*

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ERRATA

Page 405, line 3 should read: (Cort, 1931, Cort, Otto and Spindler, 1930), and in Louisiana occurs predominantly." etc.

Pages 572, 574, and 576, dates of the citation "Kartman and Lonergan" should read "1955," instead of "1953."

Page 575, Fig. 2. Decimal points have been lost between digits of the first four and the sixth values on the ordinate.

Page 578, after the citation "Kartman and Lonergan" the journal should read "Bull. Wld. Health Org."

BOOKS AND MONOGRAPHS RECEIVED

Babić, Ivo, Marcel Delak and Davor Mikačić (Veterinary Faculty, University of Zagreb). NAMETNICI I NAMETNIČKE BOLESTI KONJA. (Parasites and parasitic diseases of the horse). 305 pp., 111 textfigures, 15 pp. index. Jugoslav Academy of Science, Zagreb.

Faust, Ernest Carroll (A.B. Oberlin College 1912, M.A. 1914, Ph.D. 1917, Illinois, William Vincent Professor of Tropical Diseases and Hygiene, Tulane University). AMEBIASIS. xi + 154 pp., 6 chapters, 12 figures, 4 pp. author index, 10 pp. subject index. Charles C. Thomas, Springfield, Illinois. $4.75.

Kudo, Richard R. (D.Sc. Tokio 1924, Professor of Zoology, University of Illinois). PROTOZOOLOGY, Fourth Edition. xi + 966 pp., 2 parts, 45 chapters, 376 illustrations, 14 pp. author index, 48 pp. subject index. Charles C. Thomas, Springfield, Illinois.

Luria, Salvador Edward (M.D. Turin 1935, Professor of Becteriology, University of Illinois). GENERAL VIROLOGY. xiii + 427 pp., 19 chapters, 93 textfigures, 49 pp. bibliography-author index, 13 pp. index. John Wiley & Sons, Inc. New York. $8.50.

Meyer, Marvin C. (Associate Professor of Zoology, University of Maine). THE LARGER PARASITES OF THE FRESH-WATER FISHES OF MAINE, 92 pp., 6 pp. references, 4 pp. index, 2 textfigures, 8 plates. Fishery Research and Management Bulletin NO. 1, Maine Department of Inland Fisheries and Game. Augusta.

Wolff, J. W. (M.D., Professor of Tropical Hygiene, University of Wageningen, Bacteriologist, Institute of Tropical Hygiene and Geographical Pathology, Royal Institute, Amsterdam). THE LABORATORY DIAGNOSIS OF LEPTOSPIROSIS, xiv + 99 pp., 6 chapters, 5 textfigures, 7 tables, 10 pp. references, 3 pp. index. Charles C. Thomas, Springfield, Illinois.

Yamaguti, Satyù (M.D., Dr. Sci., Professor of Parasitology, Okayama University Medical School, Okayama, Japan). ILLUSTRATED KEYS TO THE ADULT CULICINE MOSQUITOES OF NORTH AMERICA NORTH OF MEXICO WITH NOTES ON GENERAL MORPHOLOGY AND BIOLOGY OF GENERA. ii + 48 pp., 149 collotype plates, 2 pp. literature, 2 pp. index. Published by author, 1952. $10.50. Obtainable from the author during his stay at Animal Parasite Laboratory, A.R.C., Beltsville, Md.

Yamaguti, Satyu (Department of Parasitology, Okayama University Medical School, Okayama, Japan). SYSTEMA HELMINTHUM. Part I. DIGENETIC TREMATODES OF FISHES. ii + 405 pp., 32 collotype plates and 11 textfigures, 10 pp. index of generic and subgeneric names and synonyms, 31 pp. index of species names, 32 pp. references. Published by the author, Tokyo, Japan, 1953. Agent, Maruzen Co., Ltd., Nihonbashi, Tokyo, Japan. $6.00 plus postage.

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